Trachoma and other eye dieases in Western New Guinea

Schubert, Hermann Cornelis Paul Maurice

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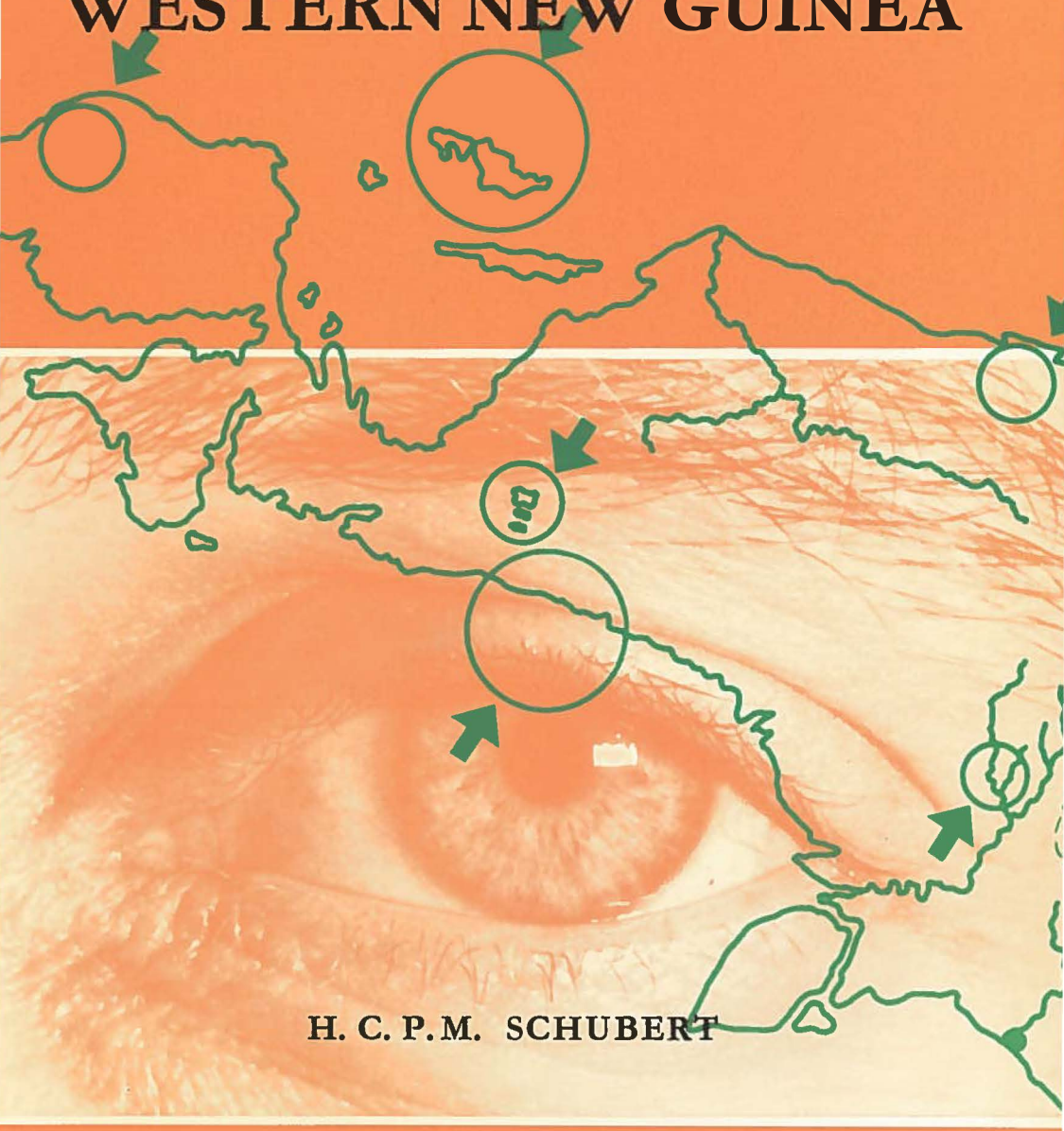

H. C. P. M. SCHUBERT

TRACHOMA AND OTHER EYE DISEASES IN WESTERN NEW GUINEA

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NETHERLANDS ORGANISATION FOR THE ADVANCEMENT OF
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Stellingen

I

Trachoom is een goedaardige oogaandoening welke echter onder invloed van bepaalde milieufactoren in maligne vormen kan ontaarden.

II

De verspreiding van trachoom kan geschieden door gezonde virus dragers.

III

De aanwezigheid van pannus is niet noodzakelijk voor het stellen van de diagnose trachoom.

IV

De Melanosis circumscripta praeblastomatosa is geen „Melanoma malignum in situ".

H. Schuermann. Der Hautarzt. 2 (1963).

V

Bij de behandeling van jeugdige personen met asthma bronchiale is de extirpatie van het glomus caroticum een waardevolle aanwinst.

W. F. Keim. Arch. Otolaryngology. 79 (1964).

VI

Bij stereomicroscopen is behalve de gewone microscoopvergroting ook de vergroting van de binoculaire parallax van belang.
De laatste wordt door de fabrikant meestal niet opgegeven.

VII

De recidiverende polychondritis is een auto-immuunziekte.

Ann. of Int. Med. 60 (1964).

VIII

Er bestaat een vorm van familiale bilaterale strio-pallido-dentale verkalking welke niet berust of Albright's hereditaire osteodystrophie.

G.W. Bruyn, G. Th. A. M. Bots and A. Staal.
Psych. Neurol. Neurosurg. 67 (1964).

IX

Bij partiële larynxresectie wegens carcinoom is voorbestraling minder gewenst.

X

Kennis van milieu omstandigheden in de meest uitgebreide zin is van fundamenteel belang voor de studie van de geografische pathologie.

Stellingen behorende bij H. C. P. M. Schubert
Trachoma and other eye diseases in Western New Guinea,
Groningen 1964

RIJKSUNIVERSITEIT TE GRONINGEN

TRACHOMA AND OTHER EYE DISEASES IN WESTERN NEW GUINEA

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR
IN DE GENEESKUNDE
AAN DE RIJKSUNIVERSITEIT TE GRONINGEN
OP GEZAG VAN DE RECTOR MAGNIFICUS DR. F. H. L. VAN OS,
HOOGLERAAR IN DE FACULTEIT DER WISKUNDE EN NATUURWETENSCHAPPEN,
IN HET OPENBAAR TE VERDEDIGEN
OP WOENSDAG 21 OKTOBER 1964 DES NAMIDDAGS TE 4 UUR DOOR

HERMANN CORNELIS PAUL MAURICE SCHUBERT

GEBOREN TE ZEIST

TE ASSEN BIJ

VANGORCUM & COMP. N.V. – DR. H. J. PRAKKE & H. M. G. PRAKKE

PROMOTOR: PROF. DR. H. M. DEKKING

Aan de nagedachtenis van mijn moeder

Voorwoord

Bij het verschijnen van dit proefschrift breng ik gaarne mijn dank uit aan allen die hebben bijgedragen tot het tot stand komen daarvan.
Hooggeleerde Dekking, Hooggeachte Promotor, het is reeds enige tijd geleden dat ik mijn opleiding bij U beeindigde. De jaren in Nieuw-Guinea doorgebracht hebben mij steeds duidelijker doen beseffen welk een voorrecht het was onder Uw leiding tot oogarts te worden opgeleid.

Het stemt mij dankbaar dat Gij, die bekend zijt met het oogheelkundig onderzoek in de tropen, bereid waart als mijn Promotor op te treden.
Hooggeleerde Kranendonk, de ruime faciliteiten welke U mij verleende in Uw functie als Adjunct-Directeur en later als Directeur van de voormalige Dienst Gezondheidszorg Nederlands Nieuw-Guinea hebben het mogelijk gemaakt dit onderzoek in deze vorm te verrichten.
Hiervoor ben ik U erkentelijk.
Uw persoonlijke belangstelling en het vertrouwen dat U in mij heeft gesteld waren voor mij een stimulans.

Veel dank ben ik verschuldigd aan de collegae J. W. van der Kouwe Dr. A. S. Kalwij, E. C. M. Janmaat en J. ten Brink, in wier ressort het onderzoek werd verricht. Zonder hun enthousiaste medewerking had dit onderzoek niet kunnen worden verricht.
Zeer geleerde Bruyn, waarde vriend, Uw waardevolle bijdragen en kritische beschouwingen waren voor mij een grote steun bij het bewerken van dit proefschrift. De originele en enthousiaste wijze van benadering van vraagstukken, welke U zo eigen is, was voor mij vaak een bron van inspiratie.
Geleerde Wachters, voor Uw grote zorg besteed aan de zo tijdrovende vervaardiging van de microfotografische documentatie ben ik U zeer erkentelijk.

Geleerde Bronts, U dank ik zeer voor de statistische berekeningen in hoofdstuk III.

Geleerde Worst, Uw opbouwende kritiek bij het doorlezen van het manuscript werd door mij op hoge prijs gesteld.

Mevrouw R. Bruyn-Koolschijn ben ik zeer erkentelijk voor de vertaling van het manuscript in het Engels.

Tenslotte dank ik de leden van het voormalige Binnenlands Bestuur, Zendelingen, Missionarissen, Papoea dorpshoofden en verplegers voor hun persoonlijke medewerking en goodwill. Zonder deze zou uitvoering van het onderzoek onmogelijk zijn geweest.

De meeste dank ben ik verschuldigd aan mijn moeder, die onder moeilijke omstandigheden mijn studie mogelijk heeft gemaakt.

Contents

FIG. 1. - Geographical position of Western New Guinea

Introduction

GENERAL DESCRIPTION OF WESTERN NEW GUINEA[1, 61, 65, 91]

The total area of the western part of the island New Guinea is about 416.000 square kilometres, which exceeds the combined area of Italy and Austria.

Till 1963 the government was Dutch; in May 1963, the Indonesian government took over and changed the name into West-Irian. The eastern part of the island (Territories of Papua and New Guinea) is governed by Australia.

Western New Guinea may be divided roughly into a northern and a southern part, which are separated by the hardly accessible and inhospitable Central Mountains, some peaks of which rise beyond the snow-line. This Central Mountain Range sends out spurs into some coastal areas both in a northerly and southerly direction and, particularly on the southern face, runs out into lowlands which largely consist of vast malaria-infested swamps intersected by many streams and rivers rising in the Central Mountain Range. Practically this entire territory is covered by bush, and is one of the most uninhabitable regions of the earth. The coastal climate is warm and humid, the annual rainfall averaging between 2000 and 3000 millimetres. However, in the Central Mountains the annual rainfall exceeds this figure; in some areas it amounts to 8000 millimetres.

The population density is one of the lowest of the earth: Western New Guinea is inhabited by about 800.000 Papuans, i.e. 2 per square kilometre. Apart from the urbanized centres, the aboriginal population inhabits widely distanced settlements, the majority of which accommodate 30 to 300 residents. Within this category, the number of settlements with less than 100 residents even dominates. In more than half of all 'villages' (55%) the number of inhabitants is less than 100.

The population is made up of numerous tribes. Contacts between the various tribes and even between various villages are few because of natural barriers and of mutual distrust. Consequently, there is a great

variety of cultural patterns and languages. The number of languages is estimated at about 200. In contrast to the rich variety of cultural patterns the common level of material welfare is one of the poorest and most primitive extant. Notwithstanding the isolation in which the various groups of the population live, there are trade contacts between the coastal areas and the in-land. Even in the interior trade routes traverse the rough ground and lead through mountain-passes at an altitude of 4000 metres.

Western New Guinea remained isolated and neglected by world trade and traffic for many centuries, which partly explains the primitive circumstances under which the population is living. This holds particularly for the aborigines in some areas of the interior who are still living in the Stone Age and never had the slightest contact with western civilization.

After the Second World War, the social and economic development of the country has been intensified and the inland opened up.

In 1962, the last year of Dutch rule, there were 22 large and small hospitals, 112 out-patient departments and 1,425 schools with 2,595 teachers distributed over the entire area.

These figures constitute convincing evidence of the intensity of medical and educational care under the Dutch Administration at the time.

THE AIM OF THE INVESTIGATION

The prevalence* of eye diseases in Western New Guinea, which is the subject of this thesis, was investigated in 1961 and 1962 in the author's capacity of governmental ophthalmologist. The investigation was carried out concurrently with the clinical work implied by his functions as Consultant Ophthalmologist to the large peripheral hospitals and as Chief of the Department of Ophthalmology of Hollandia's Central Hospital.

Apart from some limited investigations on the prevalence of trachoma in schoolchildren and an inquiry into the prevalence of ophthal-

* In this thesis the term 'prevalence' is used as recommended by the W.H.O. Expert Committee on Health Statistics. Sixth Report. Technical Report Series no. 164. Geneva 1959, for use to describe the measurement of the frequency of illnesses in existence at a particular point in time.

mological disease on the Schouten Islands by a general physician, so far nothing was known about the prevalence and social significance of eye diseases in Western New Guinea.

All research done in areas in the neighbourhood of Western New Guinea indicated without exception that trachoma is the most frequent eye disease in these latitudes.

Mann and Löschdorfer (1955) found trachoma in 53 percent of 13,717 unselected individuals in the *Territory of Papua and New Guinea*. Since the benign type of trachoma prevailed in their series, only 15 cases of blindness following trachoma were noted.

From the fact that in the Central Highlands in individuals over 30 years of age a much higher percentage of active stages of trachoma was found than in the coastal areas, the inference was drawn that trachoma only recently was introduced in the Central Highlands and is still being introduced from the coastal areas.

Löschdorfer (1955) found trachoma in 30.7 per cent of 1,867 individuals on the *Island of Niue, Polynesia*. The process here, in the large majority of cases, remained limited to the upper fornix. Only 5 cases (0.26%) of blindness due to trachoma were found. In 245 individuals in *West Samoa* and in 422 in *U.S. Samoa* the prevalence of trachoma was established to be 55.1% and 51.4% resp. In 5.3% and 0.7% resp. blindness occurred. The material in these territories was selected, however.

Swanston (1953), in a survey of eye diseases in the *Fiji islands* diagnosed trachoma in 39% of 1391 individuals.

The prevalence here remained about constant in all age groups up to the thirtieth year, after which a sharp increase up to 87.7% was noted in all age groups over 45 years. On the basis of this age distribution, Swanston came to the conclusion that trachoma in the beginning of the 20th century was much more prevalent than at the present time in which sanitary and hygienic measures are forcing it to recede. Some cases of entropion and symblepharon were noted.

Investigations by Mann (1954, 1956) and Flynn (1957) in *Australia* showed that the prevalence of trachoma in aborigines may reach a figure of 80 to 90%. Flynn mentioned healing with impaired sight in 7.3% of 4876 individuals in the Northern Territory.

East-Indonesia. According to Bakker (1927), who visited the Island of Ambon and the island-group Oeliassers (both belonging to the East Indonesian Archipelago) and who examined 9,738 individuals, trachoma is irregularly distributed among the natives and chiefly occurs in elderly people living in settlements which provide only the poorest hygienic commodities. The percentage of trachoma in all age groups of 40 years and over, averaged 8.3%. In some villages entropion occurred in 14% and corneal involvement in 20% of all cases of trachoma over 40 years of age. It is interesting to note that Bakker mentions a condition strongly resembling trachoma and commonly occurring in young children. This condition is met with already in the first years of life, after which the prevalence increases up to 18% in schoolchildren. After the 12th year the percentage of affected children decreases, in some areas even to zero per cent (cure without leaving macroscopically visible traces). Bakker suggested to reserve the name 'granulosis conjunctivae' for this condition which is exclusively characterized by 'granulae' and otherwise shows a symptom-free course. He noted that this disease is familially propagated by

domestic contagion. Unfortunately, conjunctival smears were not made and the diagnostic use of optical instruments is not mentioned.

Warouw (1935), in an investigation carried out on the island of Halmaheira (East Indonesian Archipelago) found trachoma in 2.76% of 3910 individuals examined. He emphasized that a good 50 per cent of juvenile trachoma disappears without leaving a trace when the adult age is reached. His examinations did not include the use of optical instruments.

This brief survey of the pertinent literature serves to show clearly the considerable prevalence of trachoma in the areas neighbouring Western New Guinea. In Western New Guinea itself, Löschdorfer (1958) found the trachoma prevalence among 349 schoolchildren to range from 9.3% to 56.6%.

The above-mentioned data serve to underline the desirability of a directed investigation of the population, aimed at the acquisition of a better-founded estimate of the prevalence and insight into the social significance of ophthalmological disease, particular trachoma, in Western New Guinea.

Such an investigation, in view of the relative virginity of this country which only recently has been touched by Western civilization and in which the isolation of various tribes has not yet been affected by advancing civilization, offered a unique chance to study the spontaneous course of trachoma (and other eye diseases) in ethnologic groups with widely divergent ways of living, dwelling in comparative isolation in their original surroundings. In addition, such a survey appeared to promise at least partial elucidation of the causes of possible local differences in prevalence and clinical picture as have been described in territories adjacent to New Guinea.

In order to determine the prevalence and significance of eye diseases in surroundings as dissimilar as possible, the regions to be visited were selected according to the criterium of widely divergent and sharply contrasting geographical and ethnological features.

The regions included coastal mountains, highlands, islands and swamps. The first preliminary survey, a pilot study, was made at Biak in December 1960. After this, extensive investigations followed in 1961 up to June 1962.

The survey of more regions as well as complementary investigations had been planned for the latter half of 1962 and 1963 but had to be discontinued because the period of Dutch Administration came to an end.

ORGANIZATION OF THE SURVEY

The inaccessible and sparsely populated territory of Western New Guinea is partly inhabited by semi-nomadic tribes. This makes high demands on the organization of a 'medical prospecting' survey which intends to include a representative sample of the entire population with respect to the prevalence, distribution and general pattern of trachoma.

In the absence of roads, the areas to be visited could be reached only by plane, coasters, motor-launches, proas or on foot or by a combination of any of these means of transport. The visit of distant inhospitable regions which could only be reached on foot, necessitated the use of bearers to carry apparatus, bivouac-outfit and food (since local forage is impossible) as well as of an interpreter who commands the regional language or dialect. A guide is always indispensible.

In addition, since the tribes inhabiting these distant settlements often leave their villages for a prolonged period of time on a spree of fishing, hunting, agricultural activities or doing nothing, they had to be notified of our intended stay in good time.

This implied that the region had to be visited by an Administrative Officer some weeks prior to our arrival in order to make sure that the community was present in full numbers.

Since the aborigines interpreted the absence of the doctor and his group on the announced rendez-vous and day as relieving them of their duty to be present, the programme of visiting areas was very rigid indeed and allowed of little deviation.

This constituted an extra difficulty.

It goes without saying that such a large and complicated survey was possible (and guaranteed of some success) only within the frame of a smooth working organization, such as the former Public Health Service Netherlands New Guinea, in close collaboration with other civil services, such as Local Administration, Protestant and Roman-Catholic Mission. Without their loyal collaboration, ample support and help, including transport and accommodation, this investigation would have been utterly impossible.

I gratefully acknowledge the readiness to help evidenced by the majority of Papuan village-chiefs, which attributed considerably to the succes of the survey.

The local organization in most instances was supervised by the

District Medical Officer who, if necessary, saw to the recruitment of guides and bearers.

The survey covered the following areas (fig. 2):

1. Sentani Lake (1031)
2. Wissel Lakes (1033)
3. Mimika region (1821)
4. Radja Ampat Archipelago (The Island of Misoöl and the Kofiau islands) (1522)
5. Upper Digul region (1457)
6. Tamrau Mountains (944)
7. Island of Biak (pilot study of the Schouten Islands) (155).

The numbers in brackets indicate the total of individuals examined.

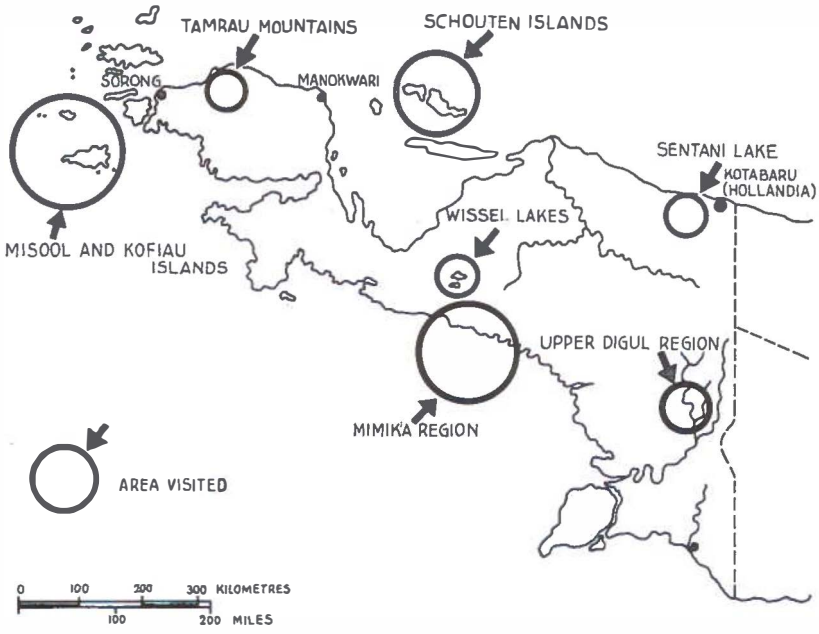


FIG. 2 - Areas visited in Western New Guinea

Because the data in the field of ophthalmological pathology collected in any of these seven areas will be dealt with separately, a description of these areas, including a concise enumeration of characteristic features and data, will be given in order to offer the reader an opportunity to acquire a reasonably accurate impression of the surroundings in which the investigation was carried out.

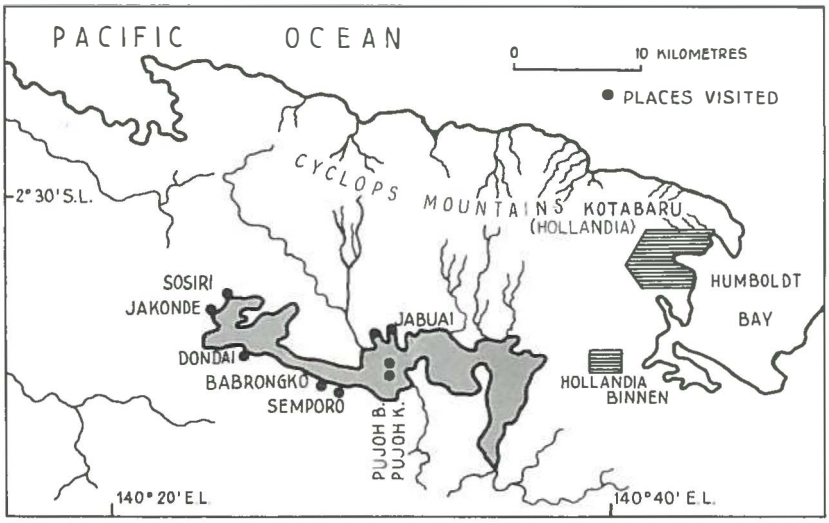


FIG. 3 - Sentani Lake and surroundings

Sentani Lake, about 30 km. long, is situated only some 12 km. from Hollandia (capital of former Netherlands New Guinea) from which it may be reached by road. The lake is surrounded by sago-marshes. Its shores and islets accomodate some 20 odd villages, inhabited by about 7000 natives. Of these, 1031 individuals were examined. The means of living include sago, horticultural produce and fish. More open contact with the outer world was not established before the Second World War, when, after the Japanese had been driven away, the U.S.Army in Lake Sentani District built the largest U.S. maintenance base of the South Pacific War Theatre. Nowadays remains of the base, such as corrugated iron and perforated airstrip matting, in addition to native material such as gaba-gaba* and atap** are used in house-building. The houses have several compartments and are typical examples of lake dwellings.

Proas are the means of communication between the villages.

After the war, many inhabitants of both sexes were employed in fastgrowing Hollandia, so that they became familiar with western products. Their original situation was also changed in other respects;

* 'gaba-gaba' is the central rib of the sagopalm-leaf. They are placed side-to-side in the construction of indigenous house-walls.

** 'atap' are dried palm-leaves, used in the construction of roofs.

to quote Metselaar[52]: 'In the course of 1954 and 1955 a few new Papuan settlements were established in the plains north of Sentani Lake. This development is an interesting result of changes in the social and economic life of the autochthonous population, which changes are closely bound up with the neighbourhood of Hollandia.

Until recently the indigenous economy was a purely subsistence economy and agriculture was practised to provide for the family only. But because good prices are being paid for fruit and vegetables in the rapidly extending capital of Netherlands New Guinea, the Papuans have an inducement to till more gardens than formerly, and sell their produce on the market'.

Schools are present in most villages; in Hollandia-Binnen there are boarding-schools and secondary schools.

Except for the very young the population goes fully clothed.

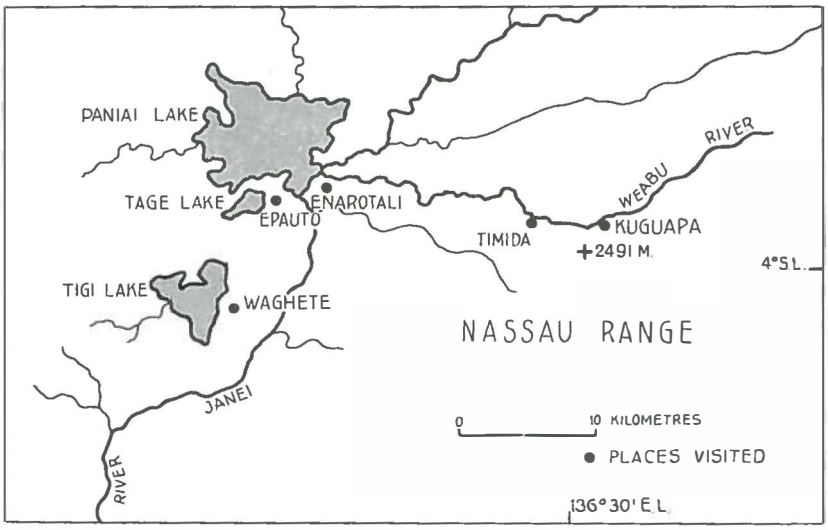


FIG. 4 - The Wissel Lakes

The Wissel Lake area was discovered in 1937, during an air reconnaissance. There are three lakes, the largest being called Paniai Lake, the smallest Tage Lake and the intermediate one Tigi Lake. All three are situated in the Central Mountain Range at an altitude of 1700 metres. This region is inhabited by about 20,000 aborigines, living in primitive huts made of rough planks, the roofs of which consist of bark. The huts are widely spaced, so that it is hardly possible to denote the agglomerations of huts as 'villages'. The village-names primarily serve an administrative purpose.

Food is provided by means of agriculture and horticulture. Next to the sweet potato which constitutes the most important staple food, sugar-cane and several kinds of vegetables are grown. The swampy soil of the deforested valleys necessitates a very extensive and complicated drainage-system, in which the crop is grown upon square elevated beds. In an aerial view, this makes the valleys look like enormous chess-boards.

Although metal tools were introduced into this area already before the Second World War, the aborigines still live largely in the Stone Age. In many parts of the Central Mountains the fields are still tilled by means of stone implements.

The women regularly go out fishing in the lakes using nets to catch crayfish, tadpoles and waterbugs. Their boats are plump, roughly

FIG. 5 - Wissel Lake area. Native plank houses with roofs made of bark. The houses have an elevated floor and an open fireplace of stones in the centre. They are void of any kind of furniture

hewn tree-trunks, which show only a vague resemblance to the finely worked slender proas of the coastal population. The natives sometimes spend the night out on the lake; to keep themselves warm they make a fire on the bottom of the canoe.

The natives of the Wissel Lake District wear no clothing in the usual sense of the word. Females only wear a sort of skirt made of tree bark, whereas the males are clothed in a penis sheath made from a long, orange gourd (fig. 6). Both sexes wear net carrying bags

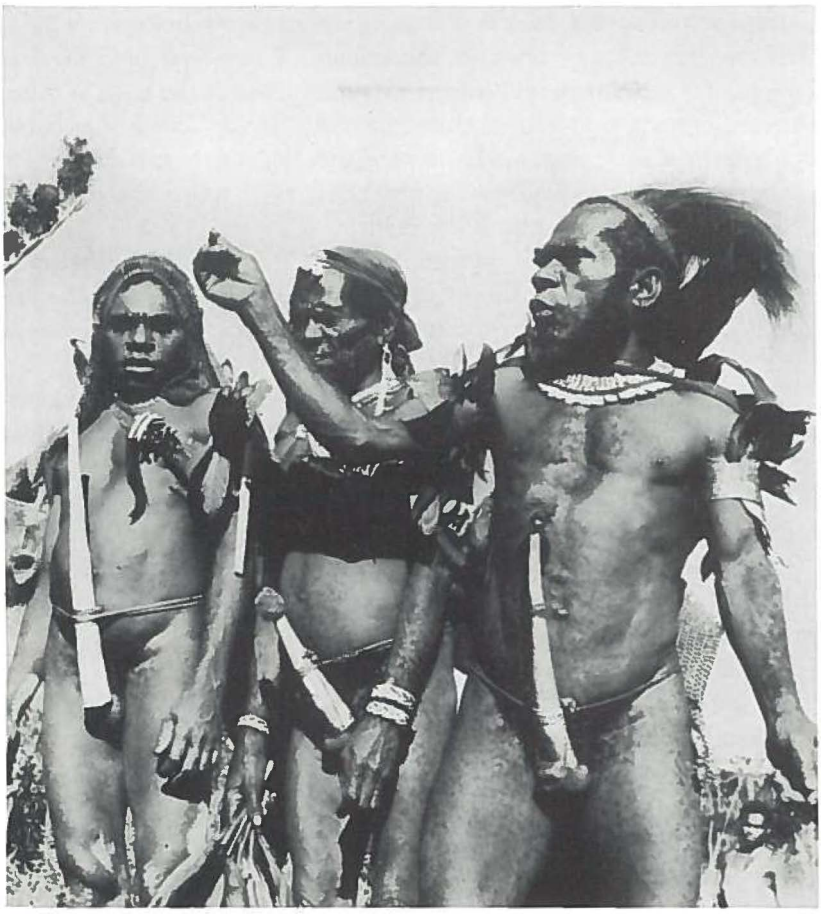


FIG. 6 - Stone Age people of the Wissel Lakes

suspended from the head and many ornaments such as beads and shells.

The climate, at this altitude, has lost its tropical characteristics. Throughout the year rain is frequent. The nights are cold, temperatures frequently dropping to 6 degrees centigrade. Notwithstanding this, the natives sleep without coverings, huddled togeter around a small fire which they keep burning throughout the night in their huts. Only the large carrying nets poorly provide some, though insufficient, protection against the cold.

Custom requires that men and women should sleep in separate huts; small children in the company of the women. When boys have reached the age of 7 years they will join the men. Just as is the case in other districts, contact between mother and infant is very close: the baby, wrapped in a little mat made of pandanus leaves, is carried by the mother in her net bag wherever she goes, even when she goes out fishing in the canoe or tilling the fields.

It is small wonder that respiratory tract infections are extremely common, particularly in infants and young children, often causing death. The ageing-process in this district begins early and it is exceptional for a native to reach an age of over 40 years.

Although this area remained in a stage of highly retarded development, as is the case in most other parts of the Central Mountain Range, it has not been quite isolated from other parts of the country. Ages-old trade routes connect the Wissel Lake District with North-and South-coast, serving the import of shells (which form part of the dowry and serve as currency), and there are also intensively used trade routes through the entire difficult country of the Central Highlands up to the Australian border[61].

Although the adverse geographical conditions prevented a full investigation of families, we succeeded in examining sufficient individuals of the various age groups.

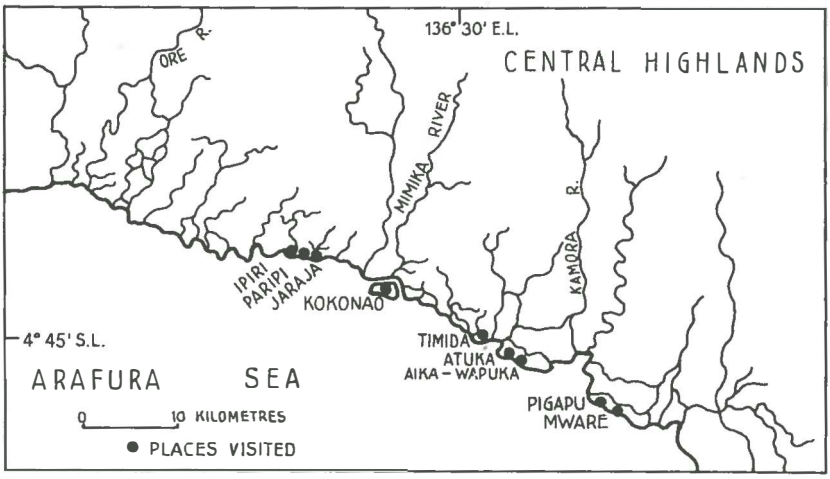


FIG. 7 - The Mimika region (Central Part)

This region consists of a triangular area situated at the South West coast of Western New Guinea. Its boundaries (the Central Highlands and the Arafura Sea) converge in a western direction on the Charles Louis Mountains. The coast-line measures 340 km. and the depth of the district increases from 30 km. near the western extremity to 105 km. at the eastern border. The area is inhabited by over 9.000 natives, of which 1821 have been examined. The country is traversed by dozens and dozens of streams, rivers and rivulets, which lead from the southern slopes of the Central Highlands to the coast, creating vast swamps. Because of this, the construction of any type of road is impossible, so that a voyage through the Mimika District is beset with difficulties.

Part of the coast is a narrow strip of sand on which the settlements are located. Immediately behind it, the completely inaccessible mangrove swamps begin. Further inland, out of reach of the tidal changes, the sago marshes and gardens are located, called 'kapal air' by the natives. Towards the east the distance between the coast (villages) and 'kapal air' (means of living) increases gradually. The countryside between the 'kapal air' and the Central Highlands is uninhabited.

The Mimika natives are a nomadic people, going in their proas up the rivers to till their gardens and down the rivers to fish. The natives are so attached to their nomadic way of living that they dislike any

FIG. 9 - Pile-dwellings along the shore of the Radja Ampat archipelago

regular employment. They work only a little under the stress of want. The population inhabits the coastal settlements only episodically, preferring to live at the 'kapal air.' The coastal villages were built and are populated by governmental influence. In their hearts the natives remain a bush-people. In the coastal villages they wear cotton clothes. In Kokonao, the centre of the Local Administration, there are several schools and boarding-schools, run by the Roman Catholic Mission.

The survey, conducted in the central coastal area, was quite successful, the population for nearly a hundred per cent having followed the request of the District Medical Officer to be present in the villages at a given date.

The villages were visited by the only means possible: a proa powered by an out-board motor.

Tide tables were essential if one did not want to get stuck in the shallow muddy delta at ebb-tide.

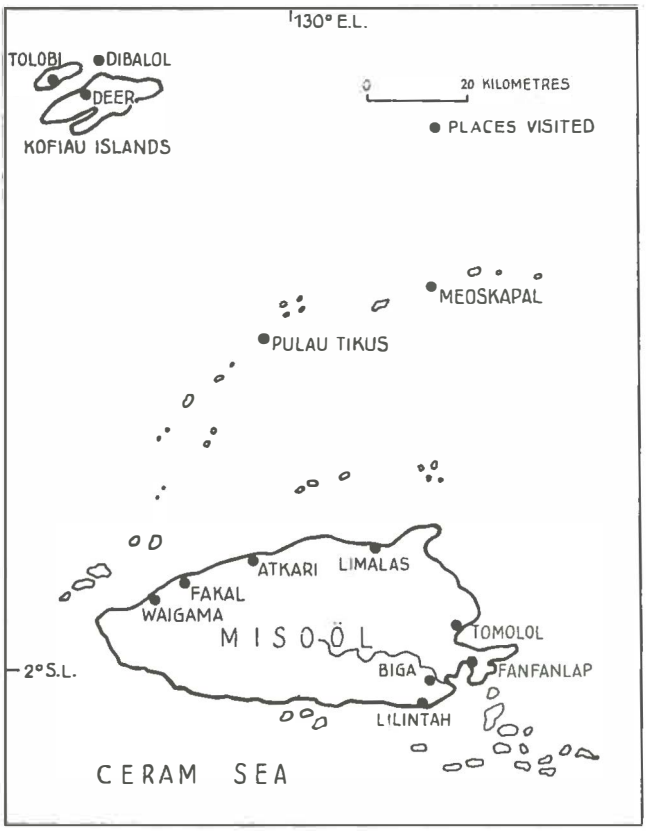


FIG. 8 - Misoöl and Kofiau Islands

The Radja Ampat Archipelago, in addition to the four large islands Misoöl, Salawati, Batanta and Waigeo, includes hundreds of small islands, of which the majority are uninhabited. By virtue of its site between the East Indonesian Archipelago and the micro-continent New Guinea, this area has for a very long time been a centre of contact between several races and tribes. At this area the inhabitants of the Moluccas, Celebes and Schouten Islands met and mixed with each other and with the local population.

From an anthropological point of view, these islands constitute an area of transition between the Malayan population of the Indonesian Archipelago and the negroid Melanesian Papuans of New Guinea.

With the exception of the inhabitants of some inland villages, the

population subsists on the yield of the fields and the sea. The waters surrounding the islands abound with fish. The island people are generally skilled sailors. Occasionally, their seaworthy proas are equipped with outboard motors.

Except for infants and very young children, the people go fully clothed. Their houses are built on piles (fig. 9), either on the waterfront, over the sea or inland. The houses contain several compartments.

Copra, damar (a sort of resin) and shells serve as trade products.

Most villages included in the programme were reached by means of a comfortable seagoing vessel. The remainder were reached by proa, rigged out with an outboard motor, which was taken along with the vessel. In the island Misoöl and the Kofiau Islands, 1522 individuals were screened; they form about 40 per cent of the population.

The Upper Digul region is named after the river Digul, the origins of which are in the Central Mountains. The river takes its course through country which gradually grows less rugged and finally traverses vast swamps before reaching the sea. The area

visited varies from sloping to hilly and is covered by bush.

Most kampongs (i.e. settlements) were reached by motor-launch, some by proa through water-logged swamp forests.

The inhabitants of this area belong to various tribes. Being of nomadic origin, they have been encouraged by the Administration only recently to settle in kampongs along the rivers. Many of these had only just been finished in 1959.

Blood- and trade-relations with surrounding tribes abound, dating from before the advent of Government and Mission (± 1930).

The houses are built upon high piles. There are separate compartments for males and females. The women only wear a grass skirt, the men nowadays wear short cotton trousers; only sporadically the original male wear, consisting of a shell covering the genitals is seen worn by old men.

About 25% (1457) of the total population of this area was examined.

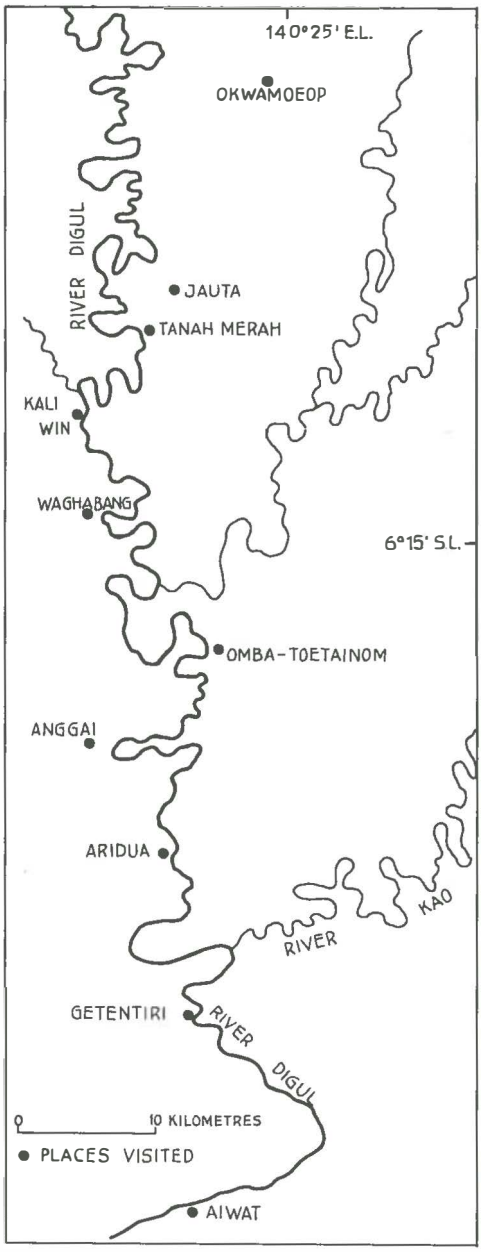


FIG. 10 - The Upper Digul region

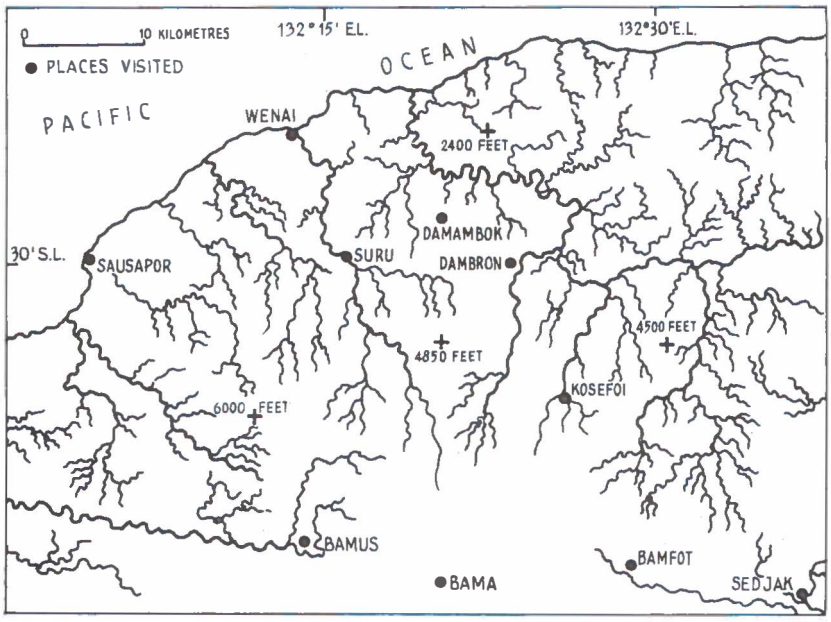


FIG. 11 - The Tamrau Mountains

The Tamrau Mountains form a coastal mountain range, in close vicinity to the ocean. This region, inhabited by the Karon-tribe, was visited by Laglaize[39] in 1877, who was the first white man to stay there for some time in order to study the manners and customs of the cannibalistic Karons. Cannibalism in this area was in vogue up to the Second World War. As far as I am aware, nothing has been published on this region and population since 1879. This is partly owing to the utter inaccessibility of the area, which makes the apparition of a white man an exception.

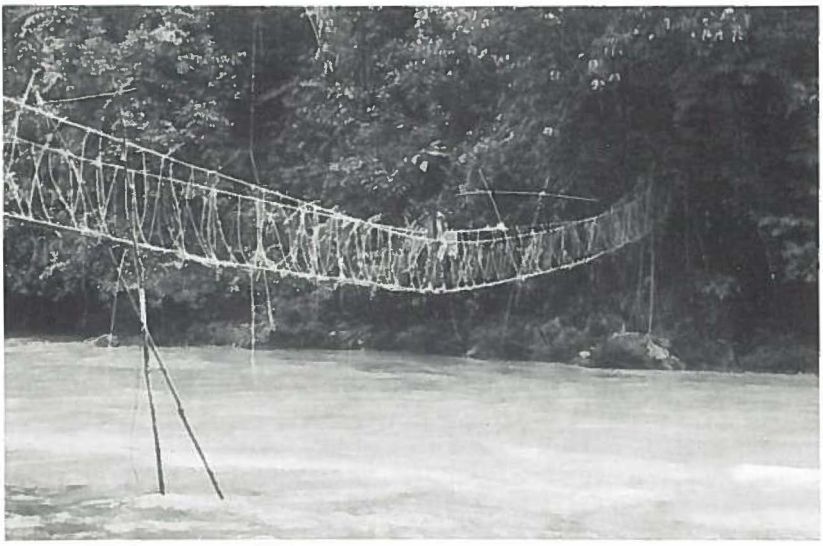
The area is made up of extremely rugged mountainous country, heavily covered by thick bush which prevents any panoramic view and permanently hides the sky from the traveller's gaze. Between the steep slopes, numerous rapidly-flowing rivers seek their way to the ocean.

Laglaize, who penetrated the inland over a distance of 2 day-marches and who had to cross more than thirty times fast-flowing rivers, described his journey as 'hard and extremely tiring'.

The journey, made for the medical survey of this region lasted more than three weeks, in the course of which period the mountainous

FIG. 12 - Transport difficulties in the Tamrau Mountains. The bearers are carrying all the apparatus packed in sealed tins

FIG. 13 - Tamrau Mountains. Deep rapids necessitate construction of bridges, the apparent frailty of which intimidates the un-initiated



country ever-increasing in ruggedness and inaccessibility, was penetrated on foot. Starting from the coast, along hardly discernible jungle trails and wading along river-beds, occasionally building bridges to cross otherwise unnegotiable rivers, we covered a distance of 45 kilometres (as the bird flies) inland.

The semi-nomadic Karons only temporarily stay in their settlements and pass the better part of their time either by hunting with bow and arrow or by tilling the ladang-fields in which the sweet potato, sugar cane and banana are grown. Often, these fields are at a very large distance from the settlements, which explains the presence of primitive shelters in the gardens.

The settlement houses are built on piles and contain only one compartment for several families. Since whole settlements are occasionally shifted to another site, their location on a map is subject to changes. The males only wear a tjawat (i.e. loin-cloth), whereas the females boast a cotton full skirt.

The Karons are in regular contact with the villages along the ocean-shore. Already in 1879 Laglaize wrote that people from Biak and Numfoor and even the Malay regularly visit the coast for purposes of trade: 'When the proas have arrived, the Karons descend from the mountains, taking along slaves and dried skins of Birds of Paradise and exchange these for beads, hatchets and bracelets.' Laglaize also mentioned a Numfoor-settlement on the shore with which the Karons kept up a lively contact. The ethnologist Reverend Dr. F. C. Kamma, who stayed in this region for a considerable period, confirmed this, mentioning many contacts of the Karons with other people, e.g. with smiths from Biak.

By means of a seagoing vessel chartered in Sorong (fig. 2, page 6) we reached the Tamrau shores at a certain point, where the Local Administration had already recruited a guide, an interpreter and bearers and had notified the population.

In spite of this, it proved impossible to examine more than 944 individuals owing to the thin population of the immense area and due to the fact that many convocated did not present themselves. An estimated 60 per cent af all inhabitants of an area of 600 square kilometres was examined.

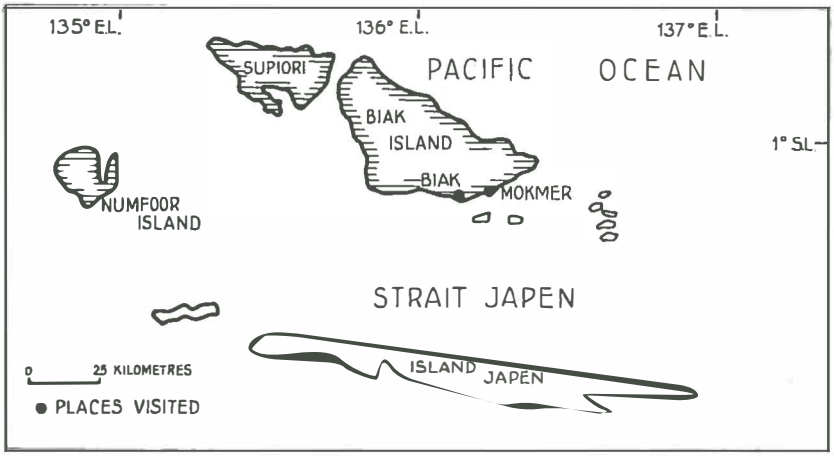


FIG. 14 - The Schouten Islands

The barren coral islands Biak, Supiori and Numfoor, together form the group of the Schouten Islands, located off the North-coast of Western New Guinea. Biak had an international airport.

The white coral ground together with the absence of hills and of tropic rain-forests in many places, cause a blinding glare, particularly disagreeable in the island Biak.

The inhabitants of these islands, constituting a single ethnic group with one language, have since olden times been daring seafarers who used to penetrate far into the East-Indonesian Archipelago by proa. This explains the presence of Biak-Numfoor influences recognizable anywhere from along the North-coast of Western New Guinea up to the Radja Ampat Archipelago.

In times past, these highly developed and energetic island-people played a prominent role in the history of West New Guinea's north coast. Under the Dutch Government they figured prominently in the development and civil service of the country and contributed many individuals for jobs in education, teaching and government.

Numfoor is a small island with only poor economic possibilities; this causes many men to earn their living in the industry in Manokwari (fig. 2, page 6), the nearest large city on the main-land.

Biak, inhabited by about 35,000 people, together with Supiori and Numfoor is among the most densily populated areas of Western New Guinea.

As has already been exposed more fully in the preceeding pages, some previous investigations concerning the prevalence of eye diseases in Western New Guinea as well as the pilot study which I carried out at Biak, indicated that trachoma is by far the most frequent eye disease both in Western New Guinea and its surrounding territories.

As trachoma is an extremely chronic condition, which only after many years may endanger the visual acuity, the evaluation of its significance *cannot* be derived from any research based upon a selected group of the population, such as the easily accessible group of school children, although this is often done. It is only possible, if any measure of reliability is desired, when a truly representative sample of the total population of a given area is examined.

This consideration constituted the criterium according to which the investigation was started and completed: in order to meet as fully as possible the above mentioned prerequisite, a 'sampling unit' was chosen as a basic unit for the screening of the population: each sampling unit included all the tenants of one kampong-hut. Since many huts or houses are occupied by two or three families, a sampling unit may comprise 15 or even more individuals.

Because the screening was occasionally combined either with mass screening for other diseases by the District Medical Officer or with an anti-malaria campaign, the kampongs (i.e. settlements) could often be screened in toto, all the tenants of all houses being present. If such good luck did not hold for a variety of reasons, for instance in very large kampongs, every other or every third house was excluded.

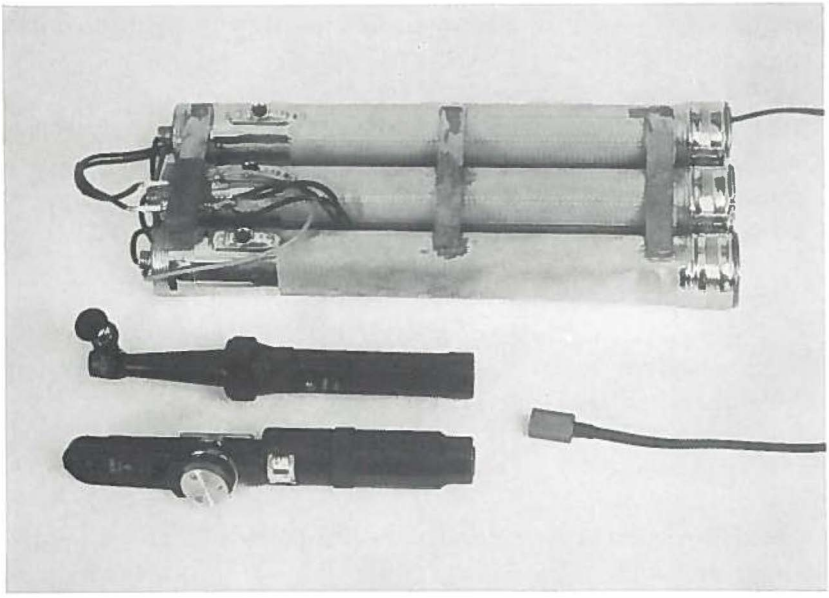
During the examination, I was assisted by a mantri (i.e. native medical assistant), who was put at my disposal by the District Medical Officer. The mantri being a Papuan and occasionally native from the area visited, by virtue of his being familiar with the local language and customs often proved to be an invaluable help.

Place of examination

The ophthalmologic examination was invariably carried out indoors, for instance in a kampong-house, a school, an out-patient wing or a church, in order to be able to work in subdued light. Occasionally it proved necessary to construct an enclosed working-space from palm

FIG. 14 - Occasionally, ophthalmological examination necessitated the construction of a dark room. To this end the natives showed great ingenuity in using natural means.

FIG. 15 - Ophthalmoscope and hand slit-lamp with power supply. Both instruments, having an identical plug, can be interchanged within a matter of seconds.



leaves (fig. 14). The dark walls of the houses, often made of gaba-gaba, formed an ideal back-ground during the examination. People were always quite ready to help in remedying any imperfection, such as closing gaps in the walls and roof if the black-out proved insufficient.

The following instruments and accessories were used:
- hand slit-lamp, fitted with a loupe of 25 dioptres.
- ophthalmoscope.
  Both instruments, fitted with 6V/5W bulbs, in their category were among the most powerful available at the time. They were fed by a specially constructed power supply, consisting of 15 batteries, connected in series of 5 each, so that a slight over-load was obtained. One set of batteries was sufficient for the examination of at least 750 individuals. Slit-lamp and ophthalmoscope, having an identical plug, could be interchanged within a matter of seconds (fig. 15).
- Desmarres lid retractors
- conjunctival scrapers
- glass spatulae for depressing the upper fornix
- boxes containing clean numbered object-slides
- spirit-burner.

The following solutions were used:
- phenylephedrine 10%; this vasoconstricting drug facilitated the examination when conjunctivitis or papillary hypertrophy was present
- surface-anesthetic ('Novesine' Wander)
- mydriatic ('Mydriaticum Roche', a fast acting derivative of tropaic acid)
- fluorescein
- ethyl alcohol
- methyl alcohol
- cotton-wool.

The conjunctival smears were fixed in methyl alcohol immediately and stained later at the Central Hospital at Hollandia.

Procedure of examination

General inspection of the eye and immediate surroundings was followed by examination of the lower eyelid and lower fornix by means of

the hand slit-lamp. Next followed the cornea, anterior chamber, iris and the part of the lens which was visible through the undilated pupil. If posterior synechiae were suspected, Mydriaticum Roche was instilled. The upper corneal limbus was closely inspected both in direct light and by means of retro-illumination. If a superficial keratitis was suspected, fluoresceine was used. Finally, the upper eyelid was everted, the upper fornix was depressed by means of a glass spatula and the upper tarsus and fornix were examined by means of the hand slit-lamp. Examination of the ocular fundi was not a routine item. This being very time consuming if done properly, it was not feasible to use it as a routine procedure under field conditions. Ophthalmoscopy was performed only when a deep disorder was suspected.

The various manipulations required for the procedure outlined above, including the procedure of taking the conjunctival smear, were strikingly well tolerated by both young and old aborigines, even by those who for the first time in their life became familiar with an electrical instrument.

Because of the marked activity of the trachomatous process in young children, much attention was devoted to the younger age groups. Therefore the age group 1 to 10 years has been sub-divided into more groups in the diagrams.

Age

As is the case in many underdeveloped countries, where the population does not live according to established concepts of time, and in the absence of a Registrar's Office, the determination of the age can only be an estimate.

One should further notice that chronic malnutrition causes a retardation of growth in the infants, who therefore look younger than they are. At a more advanced age the situation is reversed; as compared with Western standards the process of ageing starts earlier, and therefore in some parts of Western New Guinea a 40-year-old looks like a grey-haired 70-year-old.

In some districts the archives (covering several years) of the District Medical Officer were put at my disposal; these archives were very accurate as far as the younger age groups go. In those areas where

these data were not available, the age had to be estimated. In this, the help of the Papuan mantri and others experienced in the field, proved invaluable.

Reduction of visual acuity

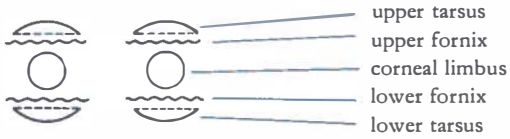
Reduction of visual acuity was assumed when pathological processes in the ocular media were observed, such as corneal opacities, pannus encroaching on the pupillary area and cataract.

Blindness

Individuals were regarded as blind when the visual impairment prevented their participation in common daily life. Such 'economical blindness' was considered to be present when the visual acuity was less than 2/60 (inability to count fingers at a distance of 2 metres).

Recording of data

In order to record the findings with a minimum loss of time and an optimum of information, a slightly simplified modification of Ching's diagram was used. All findings were entered schematically in the diagram, if necessary together with a brief note.



Ching's diagram, slightly simplified.

Example

The above diagram lists the following information:

- Male, 46 years old.
- Right eye: arcus senilis.
  corneal vessels and corneal infiltration extending 2 mm

and 3 mm, respectively, from the superior limbus.
small immature follicles located on upper tarsal surface.
presence of small, white, deeply located follicles in the upper fornix.
over whole of lower fornix and lower tarsus large, sausage-shaped, yellow, prominent follicles are present.

– Conjunctival smear no. 284.

– Left eye: arcus senilis.
inactive pterygium, extending 3 mm over the medial limbus.
slight papillary hypertrophy at upper tarsal border and adjacent supratarsal conjunctiva.
slight cicatrization located laterally in lower fornix and on lower tarsus, with some small follicles in between.
dense corneal scar, located in lower temporal quadrant, near to the limbus.

The advantages of this type of recording are:

1. simplicity: the findings are sketched in the diagram.
2. compactness: only little space is needed, which is important in mass screening.
3. diagnosis is not required on the spot, but may be postponed until the smears have been examined. The diagram gives a rendering of the clinical picture, readable at first sight.

*Photographic documentation**

Since a picture often conveys more than a thousand words, in appropriate instances the disorder was photographed by means of a single-lens reflex camera, using 24 × 36 mm film, provided with automatic diaphragm, extension tubes, double wire release and transistorized electronic flash unit. During field work, the pictures were taken by hand, without using a tripod or head-rest; in appropriate cases the

* The photographs in this thesis were made by the author, with the exception of figs. 6, 9 and 36 which are published with kind permission of the Royal Tropical Institute Amsterdam. The microphotographs were made by Dr. J. J. Wachters of the Department of Microphotography, Institute of Pathology, State University of Groningen, Holland.

patient's head and everted upper eyelid were steadied by an assistant. All the pictures of ocular pathology, shown in this thesis, were taken in this way.

Facilities

The organization facilities of the Public Health Service Netherlands New Guinea and of other services already mentioned were made available for the benefit of the survey. Other facilities included the help of the District Medical Officer, the locally available medical assistant and the clinical laboratory of Hollandia's Central Hospital. Recording, compilation, elaboration of data and diagnosis of conjunctival smears were done by the present author.

Part 1 - Trachoma

GENERAL INTRODUCTION

Trachoma is a disease distributed widely throughout the world. According to W.H.O. estimates about one sixth of the world population suffers from this disorder, which for its complications is feared in many countries. Trachoma still is the most frequent cause of blindness in the world to-day.

Actual knowledge of this disease has been summarized in the Reports of the World Health Organization Expert Committee on Trachoma (1952, 1955, 1962), the advice of which was used as guidance in our investigation.

Particularly in the following paragraphs: Definition, Classification, Clinical Diagnosis, Laboratory Diagnosis and Differential Diagnosis much has been adopted from the W.H.O. Reports.

DEFINITION OF TRACHOMA

Trachoma is a specific communicable keratoconjunctivitis, usually of chronic evolution, caused by an agent belonging to the psittacosis-lymphogranuloma-trachoma (PLT) group of atypical viruses, and characterized by follicles, papillary hyperplasia, pannus, and, in its later stages, cicatrization.

The symptoms mentioned in this definition usually develop in a certain sequence which constitutes the basis for a classification at several stages.

The most current classification, which is also recommended by the W.H.O. is the one suggested by Mac Callan.[45, 46]

Mac Callan distinguishes four stages, the main features of which are enumerated concisely below.

CLASSIFICATION OF TRACHOMA

STAGE I. INCIPIENT TRACHOMA

This usually is of insidious onset, with relatively few symptoms, so that it is often diagnosed by chance. In this stage a slight punctate hyperaemia develops along the upper tarsal border and occasionally on the upper tarsal conjunctiva, caused by dilatation of capillaries between which small immature follicles develop. In due course the hyperaemia changes into conjunctival papillary hypertrophy. This type of trachomatous eruption may be limited to this stage for months or even years without causing much discomfort. Stage I may progress gradually into

STAGE II. ESTABLISHED TRACHOMA

In this stage the conjunctival hyperaemia has become intensified with accompanying papillary hypertrophy and more or less marked subepithelial infiltration. Simultaneously the follicles mature, become more numerous and may also be present on the caruncle, plica semilunaris, corneal limbus and the lower eyelid. The numerical proportion of papillae to follicles varies greatly in different cases which makes subdivisions of stage II such as follicular and papillary types feasible. In characteristic cases the follicles, because of their necrotic degeneration have the aspect of boiled sago; the follicular contents are squeezed out easily. In this stage ptosis may develop. The trachomatous pannus preceded by punctate keratitis, most frequently develops here, but may occur much earlier. Stage II may progress gradually into

STAGE III. CICATRIZING TRACHOMA

The follicles are gradually replaced by scar tissue. The formation of scar tissue is most pronounced in the upper eyelid and may vary from gross, macroscopically easily visible, connective tissue strands to very delicate white lines, sometimes forming intricate star-shaped or cobweb-like patterns. In between these papillary hypertrophy and follicles are present. In this stage, because of stenosis and obliteration of crypts and gland-ducts, cysts may develop which may calcify later on. At the close of stage II and in stage III the pannus extends.

STAGE IV. HEALED TRACHOMA

This stage has been reached when active trachomatous inflammation is no longer present. The conjunctiva is cicatrized, atrophic and smooth, and the pannus has become inactive. In less serious cases the pannus may disappear completely, leaving behind only ghost-vessels in a clear cornea.

Depending on the extent of cicatrization, entropion, trichiasis, symblepharon and xerosis may or may not develop. In their turn, these secondary conditions may cause tertiary complications such as keratitis, ulcera, and so on. Visual acuity at this stage therefore may vary from 6/6 to perception of light only.

The clinical course of trachoma may vary considerably. Any of the stages may last months or years before developing into the next one. In addition, progress into a subsequent stage does not always follow.

The disease at any stage frequently heals spontaneously without leaving any cicatricial tissue (Nataf). There are also considerable variations in the extent of follicles, papillary hypertrophy, pannus and scar formation. The extent of these various pathological conditions need not run parallel to each other. If one takes into consideration that the various types either may be infected with microorganisms or develop as 'trachome pur', then the polymorphous character of the disease is readily understood.

Mac Callan's classification therefore may be considered only as merely a general sketch of a theme upon which many variations are played by nature.

Clinical diagnosis

The clinical diagnosis of trachoma requires the presence of at least two of the following signs:

1. follicles on the upper tarsal conjunctiva, limbal follicles or their sequelae (Herbert's pits);
2. epithelial or subepithelial keratitis, most marked in the upper third of the cornea;
3. pannus, most marked superiorly;
4. scars of characteristic configuration.

It will be clear from the preceding pages, that stages I and II before pannus appears may offer difficulties in the differential diagnosis with other types of follicular conjunctivitis, especially so if the patients concerned are individual cases from a region of which little is known about the general character of prevailing follicular eye diseases.

Differential diagnosis of follicular conjunctivitis

The following types of follicular conjunctivitis and follicular hyperplasia are recognized by the W.H.O. Expert Committee on Trachoma:

1. Acute follicular conjunctivitis
   a. Inclusion conjunctivitis
   b. Adenovirus conjunctivitis
      i. Pharyngoconjunctival fever (in some cases clinical manifestations of systemic disease may be minimal or absent)
      ii. Epidemic keratoconjunctivitis
   c. Acute herpetic keratoconjunctivitis

d. Newcastle disease conjunctivitis

2. Chronic follicular conjunctivitis (Axenfeld type)
3. Toxic follicular conjunctivitis
   a. Molluscum contagiosum conjunctivitis
   b. Eserine conjunctivitis and conjunctivitis due to other miotics
   c. Conjunctivitis with transient follicular hyperplasia due to miscellaneous irritants.
4. Folliculosis.

Ad. 1.a. Inclusion conjunctivitis (i.e. conjunctivitis neonatorum) is most commonly seen as an acute mucopurulent papillary conjunctivitis of the newborn, developing 7-10 days after birth. Its main site is the lower eyelid, which shows diffuse infiltration of the conjunctiva. In the first months of life follicles do not develop. If left untreated, a spontaneous cure without leaving a trace will follow in a few months (Morax, Thygeson, Hogan and Zimmerman).

Diagnosis is established by demonstrating the presence of inclusion bodies (virus of the PLT group) in conjunctival smears or by means of culture.

In children or adults Inclusion conjunctivitis invariably appears as an acute follicular conjunctivitis with scanty discharge, which in serious cases may, however, closely resemble the clinical picture as seen in newborns.

The follicles, in contradistinction to those of trachoma, are located mainly in the lower eyelid.

The inclusion bodies of trachoma and inclusion conjunctivitis cannot be distinguished from each other in the laboratory.

Ad. 1.b.i

1.d. Béal's acute follicular conjunctivitis, just as the Newcastle disease conjunctivitis, is an acute follicular conjunctivitis of short duration (7-10 days) leaving no traces.

Ad. 1.b.ii

1.c. Epidemic keratoconjunctivitis and *herpetic keratitis* are easily distinguishable from trachoma by their pathognomonic corneal changes.

Ad. 2. Axenfeld's chronic follicular conjunctivitis is the disease most easily confused with trachoma since in this condition the follicles, besides involving the upper fornix, may also develop on the upper tarsal conjunctiva.

According to Duke-Elder[15] 'the disease mainly affects children in whom adenoid hyperplasia is common. The clinical picture is essentially that of folliculosis with a super-added infection. Small, pale, rounded or oval follicles are marshalled in rows along the lower lid, raising the mucosa into little mounds. Frequently, follicles are also seen in the upper lid near the proximal border of the tarsus. Sometimes these are gathered together in lumps and they may assume a considerable size.'

Important differences with trachoma are:

1. the lack of inclusion bodies
2. spontaneous cure without sequelae of any kind after one or two years.

Ad. 3. Toxic follicular conjunctivitis. Of this there are three categories:

a. Molluscum contagiosum conjunctivitis may mimic the clinical picture of a chronic conjunctivitis or even that of a fully developed trachoma with pannus and scarformation. Invariably however, a molluscum nodule is present on the lid margin. After excision of the nodule a cure will follow.

b. Conjunctivitis from miotics. This condition, sometimes seen in glaucoma patients treated over prolonged periods, for the purpose of our investigation needs no consideration.

c. Conjunctivitis due to chronic irritation. In susceptible individuals, particularly children, various irritants can cause transient follicular hyperplasia. Confusion with trachoma is unlikely however.

Ad. 4. Folliculosis. This is a non-inflammatory follicular hyperplasia, which is partly described under ad. 2.

In the classical work of Morax 'Les Conjonctivites Folliculaires' is also described localization of small clear follicles on the tarsal conjunctiva.

When complicated by bacterial infection the condition may be confused with trachoma. There are no inclusions however. The disease will heal without sequelae in the course of one to two years.

LABORATORY DIAGNOSIS OF TRACHOMA

Cytologic examination may be very helpful in differential diagnosis. In 1907, von Prowazek and Halberstädter were the first to describe the intracellular elementary body inclusion bodies in the conjunctival epithelium of Javanese sufferers from trachoma. Lindner (1910) was the first to describe the initial body-form and the intracellular development cycle of the virus. Already in 1935, Thygeson et al.[82] experimentally inoculated a human volunteer with trachomatous material filtered through a gradocol membrane of 0.6 micron average pore diameter and found that infectivity was associated with the presence of elementary bodies in the filtrate. Subsequent workers noted the far-reaching resemblance of trachoma virus with the viruses of psittacosis and lymphogranuloma venereum. On this basis, it was classified along with inclusion conjunctivitis, as belonging to the psittacosis-lymphogranuloma-trachoma group. The members of this group have a cycle of intracellular multiplication with visible elementary bodies and large initial bodies which may approach the size of bacteria.

The recent development of a reliable method of culture (T'ang et al. 1957; later confirmed by other workers) [12, 25, 49, 54, 72] made it possible to show that the trachoma virus fully meets Koch's postulates. The morphology of the intracellular inclusions will be discussed in the paragraph on cytology.

Next to trachoma, inclusion conjunctivitis is the sole remaining disorder in which inclusions may occur in conjunctival epithelium, so that in their presence differential diagnosis is limited to trachoma and inclusion conjunctivitis (Thygeson, 1960). These two diseases are easily distinguished by their different clinical course.

According to other authors,[31, 71] intracellular inclusion bodies can also be found in epidemic keratoconjunctivitis, especially during the first ten days of the disease. Also this disease, however, can be easily distinguished from trachoma as it has a completely different clinical course.

Other cytologic features of diagnostic value, although less specific, are the necrotic changes of the trachomatous follicles which precede cicatrization. These phenomena are absent in non-trachomatous follicular conjunctivitis (Kimura and Thygeson 1955, and Thygeson, 1958, 1960). The most important feature is the presence of Leber cells. These cells are macrophages often showing phagocytosed cell-fragments in their cytoplasm. Other features are the poor stainability of lymphoid cells and the presence of scattered cytoplasmic debris. Matuo (1959) stressed the diagnostic value of the number of macrophages in conjunctival smears in the differential diagnosis of trachoma.

All changes, enumerated above, are most marked in follicular material obtained by curettage or squeezing but may also be present in conjunctival smears, especially when scraping of the conjunctiva is done vigorously so that the follicles are ruptured and their contents obtained in addition to epithelial cells.

THE PREVALENCE AND SIGNIFICANCE OF TRACHOMA IN SEVERAL REGIONS OF WESTERN NEW GUINEA

The diagnosis of trachoma in the various regions was made mainly on the basis of clinical signs and symptons. Because of the general set-up of the survey the cases were also judged against the background of clinical findings in other members of the families.

Diagnosis was further based upon conjunctival smears obtained from 302 individuals. If more than one smear was taken from one individual, they were counted as only one. The results of the cytologic examination of 302 smears will be discussed in the paragraph on cytology of conjunctival smears (page 61).

The considerable differences in frequency, type, course and severity of trachoma in various countries are generally acknowledged. These differences may be striking even in neighbouring districts,[59, 96] which has also been noted in the seven regions screened in Western New Guinea. Because of this, each of these areas will be discussed separately and an attempt has been made to represent the 'inter-regional' differences as much as possible in diagrams.

In the diagrams the precicatricial stages (Mac Callan I and II) have been grouped together; the stages Mac Callan III and IV each constitute a separate group.

The diagnosis trachoma I was made exclusively in the presence of follicles. Local hyperaemia or papillary hypertrophy, even if suspect for trachoma, was not diagnosed as trachoma. In many instances it was regarded as a subclinical* type of trachoma. This was not included in the graphs. Healed trachoma (Mac Callan IV) was diagnosed in the absence of follicles, in the presence of typical scars and (or) inactive pannus in the upper part of the cornea. Frequently a slight hyperaemia or papillary hyperplasia was observed in Trachoma IV.

As will be explained later, in most districts the conjunctiva was only very partially involved in the trachomatous process. Consequently after a cure large areas of conjunctiva remained normal, which, particularly in a milieu in which even an elementary understanding of hygiene is absent, often showed unspecific irritation. Because of this, a 'classic' trachoma IV, consisting of scar tissue alone, covered by an atrophic smooth conjunctiva, was seldom observed. The same holds true for 'normal' eyes, which in those milieus often showed aspecific symptoms of irritation.

Detailed figures which form the basis of the diagrams are listed in the Addendum.

Lake Sentani

Trachoma in this region is chiefly 'trachome mixte'. Its onset is characterized by the development of white to yellowish-white follicles in the upper fornix and upper tarsus. Sometimes simultaneously, sometimes somewhat later, the lower eyelid is involved. The follicles which either may be few in number or widely scattered all over the

* A subclinical infection is an infection which is below the threshold of clinical recognition.

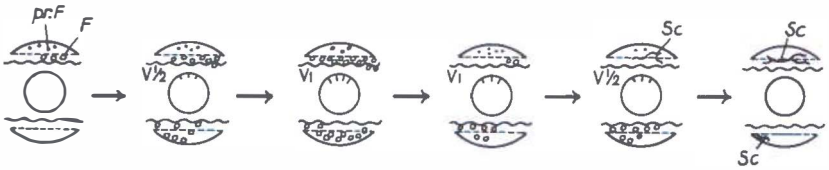
lids, in the majority of cases do not reach full development but remain immature. As a rule, the follicles are more numerous on the upper than on the lower eyelid; exceptions to this are not few however. Tarsal follicles were present in 86% of the trachoma cases in the stages McCallan I, II and III.

In the Sentani Lake area a trachomatous pannus develops as a rule at the upper corneal limbus; the vascular invasion into the cornea generally measuring 0.5 to 3 millimetres. Punctate keratitis and Herbert's pits were frequently observed.

After a period of several years (usually after the 6th year of life) the pannus becomes inactive, the vessels become 'ghost-vessels' and gradually the pannus clears up. At its extremity a crescent-shaped cloudiness is often left over, indicating the original limit of the pannus. In due time this clouded spot will disappear as well, leaving a practically clear cornea with fine vessels in it.

After the age of six, the follicles also tend to disappear (fig. 16B). The tarsal follicles sometimes leave behind either small, rounded, whitish-yellow atrophic spots or delicate cobweb-like scars on the tarsal conjunctiva. In the majority of cases they disappear without leaving a trace. The follicles which are situated along the upper tarsal border, upper fornix and on the lower eyelid may disappear without any sequelae but may leave the delicate cobweb scars that in some instances are detectable only by means of the hand slit-lamp.

Because in this district families are as a rule quite large (families with five children are no exception), the spontaneous course of the disease could be observed in all its stages. The diagrams below represent the most frequent type of development of trachoma in this area:



RIGHT EYE

Figures 16A and 16B represent the prevalence rate of trachoma (all stages) and the relative proportion of trachoma-stages according to age groups resp. In fig. 16A the dotted curve represents the percentages of all examined individuals in the respective age groups who showed trachoma with pannus. This graph clearly shows that in most trachoma cases of this area pannus is present.

FIG. 16A - Prevalence rate of trachoma (all stages) according to age groups in Sentani Lake area
The dotted line represents the percentage of the population with pannus

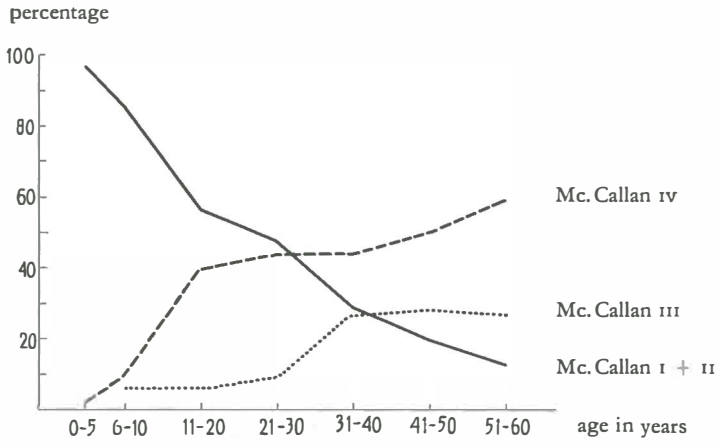


FIG. 16B - Relative proportion of stages Mac Callan I + II, III and IV according to age groups in Sentani Lake area

Since the pannus prevalence rate decreases with advancing age and taking into account that pannus will not show a restitutio ad integrum, but invariably leaves ghost-vessels, one is forced to the conclusion that a certain percentage of pannus has escaped diagnosis by the examination with the hand slit-lamp, especially among the more advanced age groups. This percentage of non-diagnosed pannus is formed mainly by very small, inactive pannus because pannus of some extent is bound to be noticed when the hand slit-lamp is used.

Although trachoma in the large majority of cases shows a mild course, three cases of unilateral reduction of visual acuity, one case of monocular blindness and one case of binocular blindness following trichiasis were noted in the Sentani Lake district. These cases should be considered as exceptions, however, since cases of early entropion and of pannus threatening to encroach upon the central corneal area were not observed.

SUMMARY:

Total number of individuals examined	1031
cases with trachoma	530 = 51%
cases with bilateral reduction of visual acuity caused by trachoma	0
cases with unilateral reduction of visual acuity caused by trachoma	3
cases with monocular blindness caused by trachoma	1
cases with binocular blindness caused by trachoma	1

An estimated 13.5 to 14% of the entire population of this district has been examined.

Wissel Lake Area

Trachoma in this area chiefly manifests itself as 'trachome pur'. Its development is as follows: The very first symptoms are slight hyperaemia and papillary hypertrophy along the upper tarsal border. These symptoms may last for months or even for a period of considerably longer duration before follicles develop at this site. The colour of the follicles varies from a clearly transparent whitishness to white, yellow-white and light yellow. Their localization may be both superficial and deep.

Occasionally small infiltrates may develop along the upper tarsal border, which are oval to oblong in shape and have a gelatinous and friable aspect. After some time, often not till many years later, the follicles increase in number (or follicles develop adjacent to the friable infiltrates), involving the entire upper tarsal border and occasionally

extending on the tarsal surface, the supra tarsal conjunctiva and the upper fornix.

In most instances, however, the process remains confined to the upper tarsal border and upper fornix. Only in 35% of the stages Mac Callan I, II and III some extension of the follicles onto the tarsus was noted. These follicles almost invariably remained immature and, in the great majority of cases, disappeared without leaving a trace.

In general, in this Wissel Lake area the condition starts on the lower eyelid at a later time than on the upper eyelid, and is much less pronounced. Here the development of follicles starts laterally and spreads from here over the lower eyelid. Often, however, the process remains confined to the lateral part of the lower eyelid.

The aspect of the follicles on upper and lower eyelids occasionally differs. For instance, the upper fornix may be studded with parallel rows of small clear superficial follicles, whereas the lower eyelid shows deep yellow-white or superficial yellow ones. Other combinations were also seen. Once in a while one finds the upper fornix covered by a diffuse, patchy, yellowish, gelatinous infiltrate.

Gradually slight scar formation develops between the follicles whatever aspect they may show and in this stage the follicles tend to disappear. This process starts at ages five to six and continues with ever increasing intensity, as follows from fig. 17B. In between the scars concrements and cysts were noticed very frequently, both in adults and in young children.

Fig.s 17A and 17B represent the trachoma prevalence rate in the various age groups expressed as a percentage of persons examined and the relative proportion of trachoma stages expressed as a percentage of all trachoma cases in the various age groups resp.

Keratitis punctata in this area was only sporadically observed. With the exception of two cases, it has not been possible to detect any form of pannus by means of the hand slit-lamp. In trachome pur, signs of secondary inflammation of the conjunctiva, by definition, are absent. Therefore pannus, even of small dimensions, would undoubtedly have been noticed; especially the active stage which is accompanied by slight local hyperaemia.

This subject will be discussed more fully in the paragraph 'Trachomatous Pannus' on page 58. In the two exceptions mentioned above,

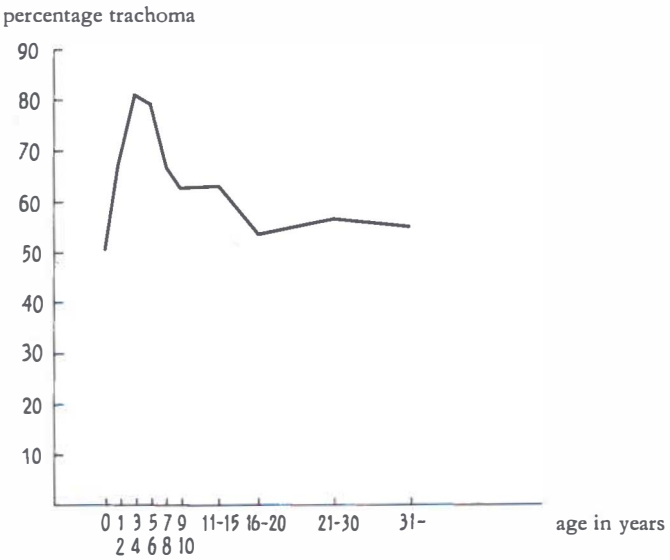


FIG. 17A - Prevalence rate of trachoma (all stages) according to age groups in Wissel Lake area

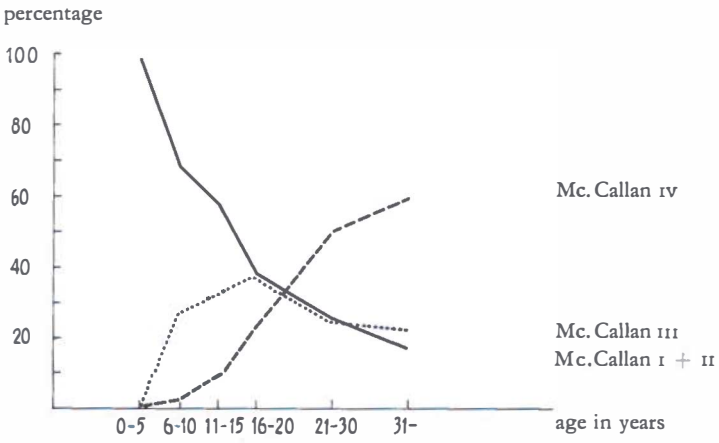


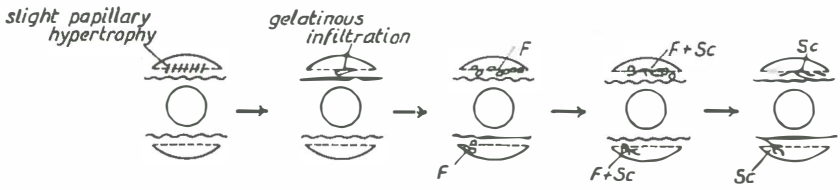
FIG. 17B - Relative proportion of stages Mac Callan I + II, III and IV, according to age groups in Wissel Lake area

attempts have been made to verify possible contacts with individuals from other areas, which might explain the presence of this different type of trachoma by assuming import of a different virus strain. Extensive inquiries in this direction failed to produce affirmative evidence for this, however. Therefore, one is forced to conclude that also in this type of trachoma pannus formation is potentially present.

Of 67 conjunctival smears, taken in this area, 44 were positive for inclusions. The findings of conjunctival smear examination are specified as follows:

32 positive for initial bodies (I B).
12 positive for I B and for Leber cells.
10 positive for Leber cells.
13 negative.

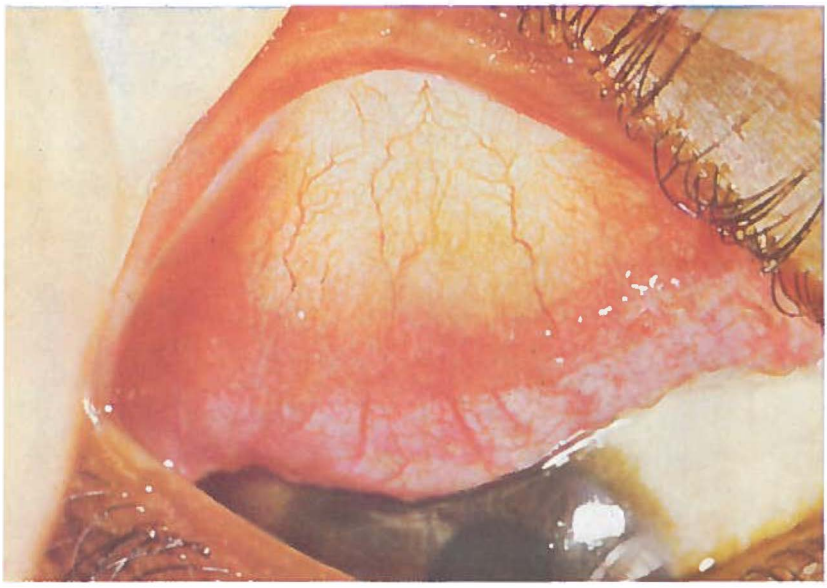
The various stages of the trachomatous process, which in the majority of cases is limited to the upper tarsal border and adjacent upper fornix, are represented in the diagram below and in Plates I to IV (page 42 and 43).



RIGHT EYE

The clinical impression gained in this district and confirmed by fig.s 17 A and B, is that trachoma in any stage of the process may heal spontaneously without necessarily progressing to the next stage. For instance, slight papillary hypertrophy at the upper tarsal border may disappear without follicle formation. Likewise, some follicles may develop which after some time disappear without leaving a trace, or leave behind slight papillary hypertrophy, such as may be present in adults. This makes it impossible to determine in these cases whether the process is in its initial stage, or has reached the final stage or even whether there is a re-infection.

It should be stressed, that in this district, the follicles do not show the features which are generally recognized as typical of a trachomatous



Plates I-IV show the development of a type of trachoma quite common in Western New Guinea

Part of the upper fornix is made visible by depressing the everted upper eyelid by means of a spatula.

PLATE I - Trachoma I.
Advanced papillary hypertrophy at upper tarsal border. Some nearly transparent follicles are located medially. Pannus is absent.

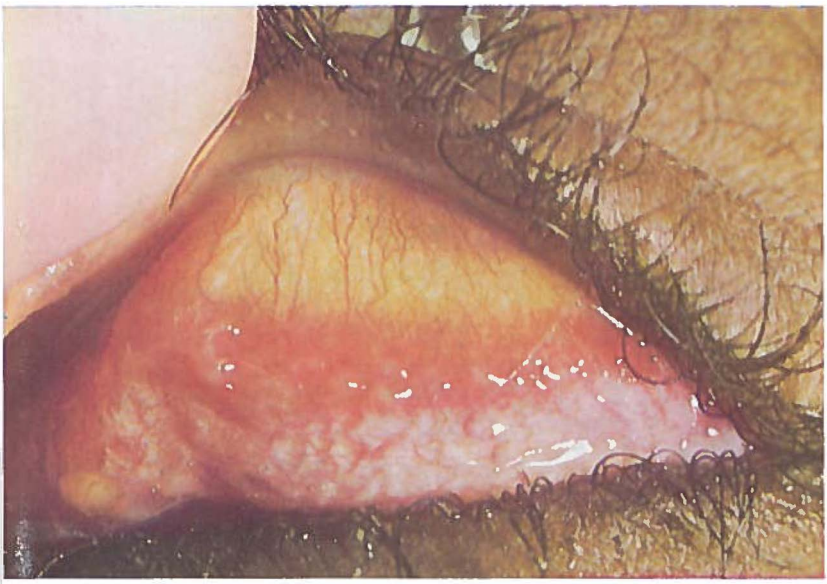


PLATE II - Trachoma II.
The entire upper tarsal border is studded with yellowish follicles surrounded by papillary hypertrophy. The follicles do not extend on the tarsal surface. In the left lower corner some large superficial follicles can just be discerned; they are not surrounded by papillary hypertrophy.
Pannus is absent.

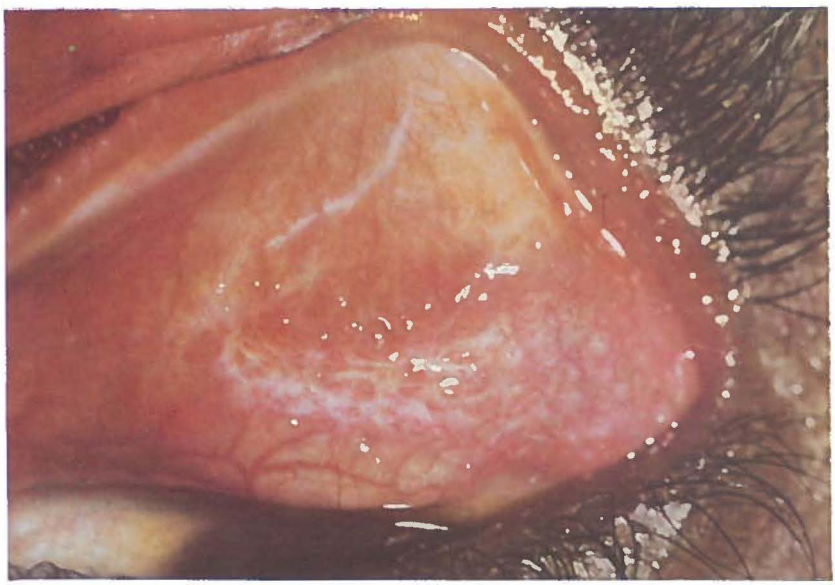


PLATE III - Trachoma III.
Nearly transparent follicles situated at upper tarsal border and adjacent supratarsal conjunctiva with scar formation in between. The conjunctival vessels cannot be seen through the scartissue. Note normal tarsal conjunctiva. (curved white line and whitish area on tarsal surface are lightreflexes). Pannus is absent.

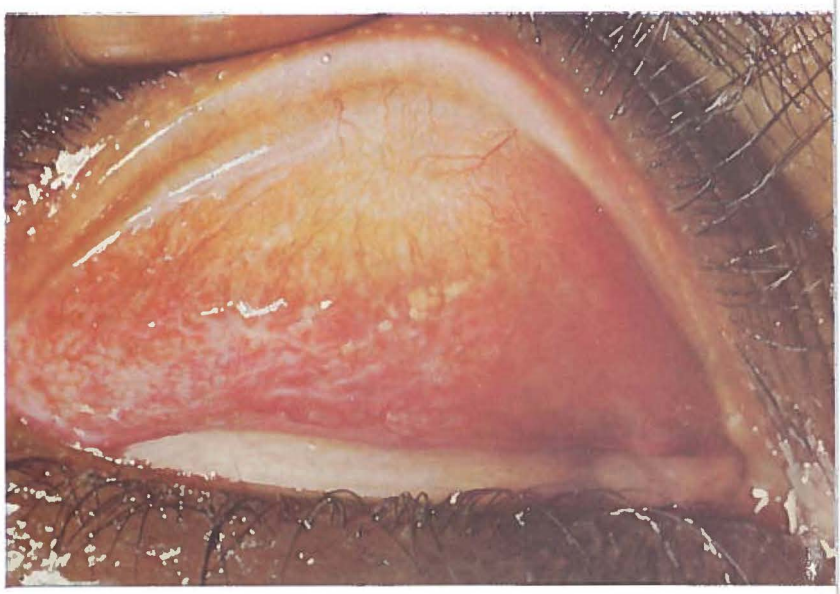


PLATE IV - Trachoma IV.
Slight cicatrization on upper tarsal border and adjacent supratarsal conjunctiva with concrements in between. Normal tarsal conjunctiva. Pannus is absent

follicle, viz.: the white colour, the aspect of boiled sago and the ease with which the contents can be squeezed out.

In this region, the follicles are predominantly white-yellow to yellow (see Plate II). Their consistency is rather firm, so that the conjunctiva had to be scraped vigorously in order to obtain sufficient material for microscopic examination.

In this area, the frequency of angular conjunctivitis in elderly people, occasionally causing severe ectropion, was striking. The etiology of this is not clear: it still remains to be determined whether deficiency of vitamin B or chronic irritation by smoke due to prolonged stay within the huts, in which fires are kept burning, are the underlying causes.

In these cases however, trachoma ran its benign course, without progressing to pannus formation.

SUMMARY:

Total number of individuals examined	1033
cases with trachoma	641 = 62%
cases with either unilateral or bilateral reduction of visual acuity caused by trachoma	0
blind by trachoma	0

An estimated 5% of the total population of this area was examined.

Mimika Region

As the crow flies, this region is only 40 miles distant from the Wissel Lakes. Just as in the Wissel Lake area, trachoma in this region manifests itself as 'trachome pur'. The follicular stage also closely resembles that observed in the Wissel Lake area, differing only in the extent of follicle formation: in general in the Mimika region follicles are more diffusely spread both on the upper and lower eyelid. Follicular involvement of the tarsus was noted in 57% of the cases showing stages I, II and III, in distinction to 35% in the Wissel Lake area. The tarsal follicles largely remain immature and disappear without leaving any sequelae. The aspect of the follicles in this region likewise varied from small, superficial and rather clear vesicles arranged in rows, to small or larger white follicles and to large yellow follicles, either prominent or not.

In all these categories, conjunctival smears showed the presence of inclusion bodies.

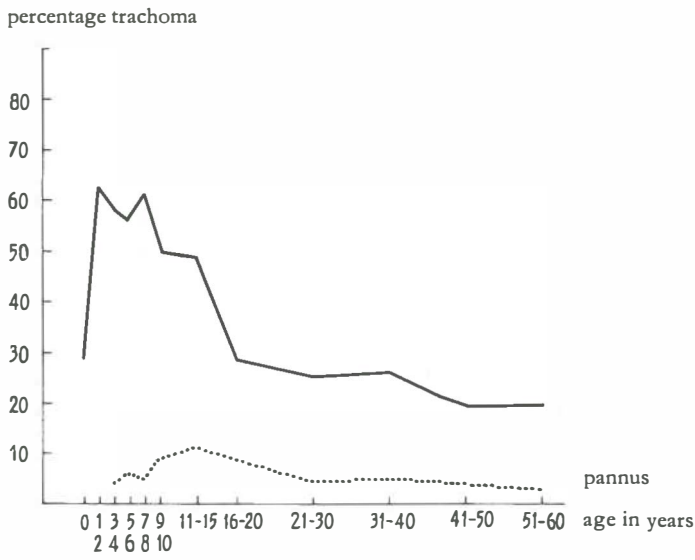


FIG. 18A - Prevalence rate of trachoma (all stages) according to age groups in Mimika region.
The dotted line represents the percentage of the population with pannus

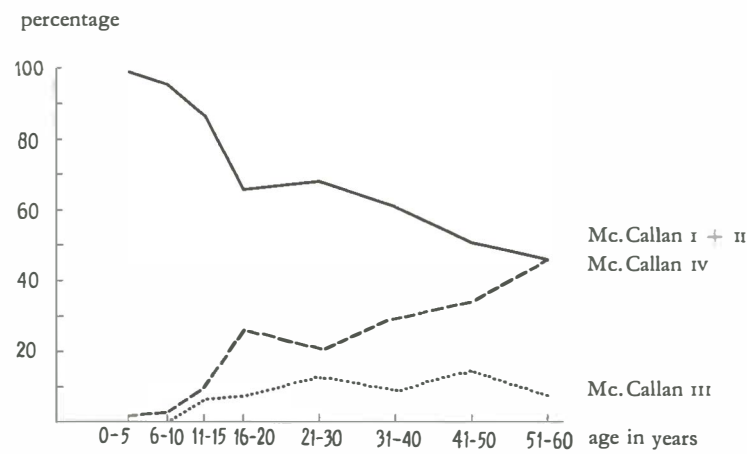


FIG. 18B - Relative proportion of stages Mac Callan I + II, III and IV according to age groups in Mimika region

In this region, the number of cases with pannus was also small, though considerably larger than the number of cases in the Wissel Lake area (14% as compared to 0.3% of all trachoma cases). The extension of vessels into the cornea ranged from 0.5 to 4.5 mm. The distribution of the rate of pannus over various age groups expressed in per cent of individuals examined is represented by the dotted line in fig. 18 A.

In the Mimika region the relatively small percentage of elderly cases with scar formation was striking, as is shown in fig. 18 A and 18 B. In addition, scar formation was slight and usually limited to delicate small strands along the upper tarsal border and adjacent supratarsal conjunctiva. Only in a few instances a connective-tissue membrane was noticed in the upper fornix, with finger-like extensions onto the tarsus, without causing symptoms.

In the lower eyelid practically no scar formation was observed.

Figs. 18 A and 18 B represent the trachoma prevalence rate of the various age groups, expressed in a percentage of individuals examined and the relative proportion of Mac Callan's stages I to IV according to age groups, expressed in a percentage of all cases of trachoma of the respective age groups.
The findings obtained on examination of the conjunctival smears show a great resemblance to those made in smears obtained in the Wissel Lake area.

Of 44 smears obtained from Mac Callan's stages I and II
19 were positive for initial bodies (I B)
4 were positive for I B and Leber cells
9 were positive for Leber cells (occasionally present in large numbers)
12 were negative.

These findings again show that follicles with microscopic signs of necrosis, such as Leber cells, do not necessarily leave macroscopically visible conjunctival scars.

SUMMARY:

Total number of individuals examined	1821	
cases with trachoma	699	= 38%
cases with unilateral or bilateral reduction of visual acuity as a result of trachoma	0	
blind as a result of trachoma	0	

An estimated 20% of the population of this region was examined.

In this area the trachoma follicles show similar variations as have been described in the areas discussed in the preceding pages.

Common variations are the gelatinous yellowish deep as well as superficial follicles, varying in size and large yellowish gelatinous patches which apparently develop by confluence of follicles.

In comparison with the findings obtained in the Wissel Lakes and the Mimika region, the superior fornix is more densely covered with follicles, whereas the frequency of follicular involvement of the upper tarsus is much higher, viz. 63% of the cases in stages I, II and III.

The follicles on the tarsal conjunctiva occasionally reach maturity; the great majority remain immature, however. In this area the lower eyelid is usually involved, either partially or completely. The affection starts laterally, proceeding medially. There is a tendency to row-formation.

As a slight chronic conjunctivitis is frequently present, the question whether the perifollicular papillary hypertrophy is an integral part of the clinical picture or should be interpreted as a secondary phenomenon could not be decided. It was observed that the superficial prominent yellowish follicles which frequently occur in adults may be associated with pannus and that they may be surrounded by scar formation. These facts prove that these follicles are not part and parcel of a fundamentally different condition. They permit as to exclude the diagnosis of Axenfeld's follicular conjunctivitis and folliculosis, which in themselves are less likely to occur in adults. The follicular process equally involves both upper and lower eyelid.

The pannus, as seen in this archipelago, generally are small, ranging from 0.5 to 3 mm. They may attain a larger size, however. The crowded villages of Fanfanlap and Lilintah form an exception. In these villages, the follicles show exactly the same localization, aspect and variations as those observed elsewhere in the Archipelago, but are frequently associated with relatively long pannus, ranging in length from 3 to 5 mm. Also, its prevalence is higher: the pannus prevalence rate expressed in percentage of all trachoma cases, which in other places of the archipelago amounts to 32%, was 61% in Fanfanlap and 57% in Lilintah.

The pannus prevalence rate expressed in percentages of individuals examined, according to age groups, has been introduced in fig. 19A (dotted line).

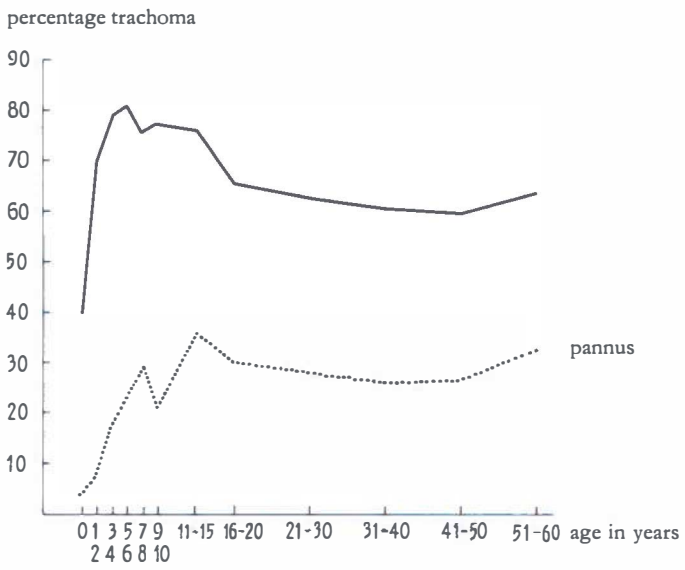


FIG. 19A - Prevalence rate of trachoma (all stages) according to age groups in Radja Ampat archipelago
The dotted line represents the percentage of the population with pannus

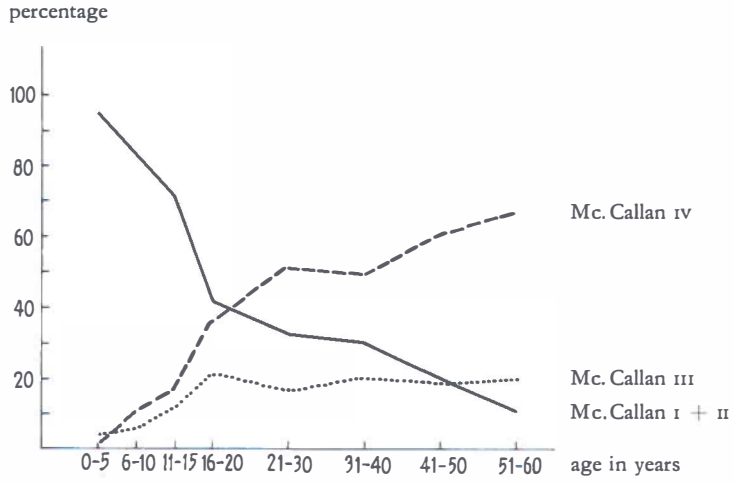


FIG. 19B - Relative proportion of stages Mc. Callan I + II, III and IV according to age groups in Radja Ampat archipelago

Scar formation chiefly consists of delicate strands of connective tissue in the supratarsal conjunctiva and the upper fornix, radiating from there to the upper tarsus. The scar formation, although markedly more intense than that observed in the Wissel Lake and Mimika area, may still be called relatively minor and benign. There is very little scar formation in the lower eyelid, if any. Cases of entropion and trichiasis were not noticed.

Fig. 19A and 19B represent the trachoma prevalence rate of the various age groups expressed in the percentage of individuals examined, and the relative proportion of Mac Callan's stages I to IV, according to age groups, expressed in the percentage of all cases of trachoma of the various age groups resp.

SUMMARY:

Total number of individuals examined	1522	
cases with trachoma	1023	= 67%
cases with unilateral reduction of visual acuity as a result of trachoma	2	
cases with bilateral reduction of visual acuity as a result of trachoma	0	
blind as a result of trachoma	0	

An estimated 45% of the total population of the island Misoöl and the Kofiau Islands was examined.

Upper Digul Region

In this area as well, trachoma mainly occurs along the upper tarsal border and adjacent supratarsal conjunctiva. Extension of the follicular process over the tarsal surface here is frequent however, amounting to 62% in Trachoma I, II and III cases. Pannus is uncommon, being noticed in only 15% of the cases, and so is punctate keratitis. The length of corneal vascular infiltration generally ranged from 1 to 3 mm., although lengths of up to 5 mm. were also seen.

The upper and lower eyelid are studded with follicles in an equally extensive degree. Scar formation, however, was considerably more frequently noticed in the upper eyelid and predominantly localized in the upper fornix and adjacent upper tarsal border.

Trachoma in the Upper Digul region mainly manifests itself as trachome mixte. The frequency of (slight) papillary hypertrophy of the conjunctiva was striking, both in trachomatous eyes, as well as in eyes without specific symptoms of trachoma. In many of these cases

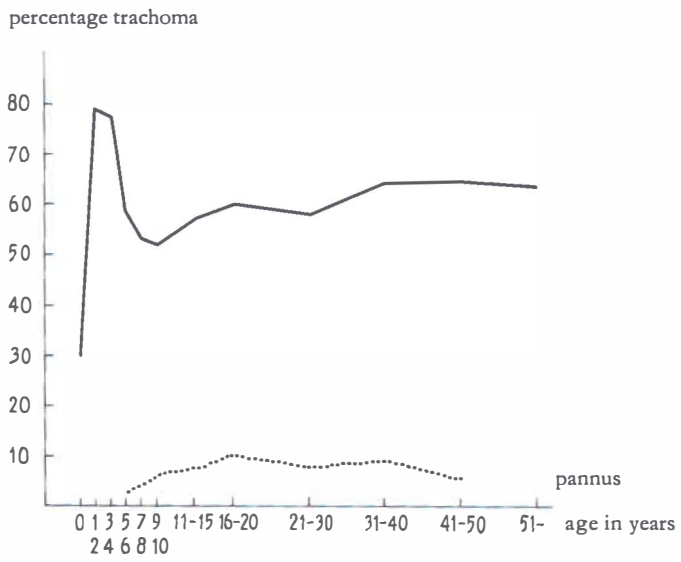


FIG. 20A - Prevalence rate of trachoma (all stages) according to age groups in Upper-Digul region
The dotted line represents the percentage of the population with pannus

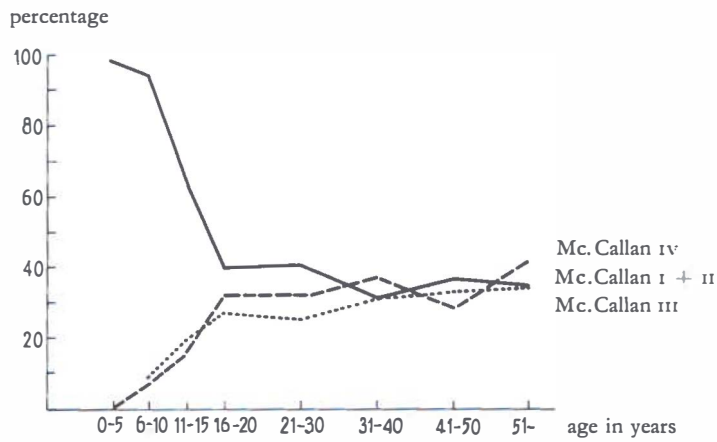


FIG. 20B - Relative proportion of stages Mac Callan I + II, III and IV according to age groups in Upper-Digul region

typical inclusion bodies were found in the conjunctival smears (see paragraph on Cytology of conjunctival smears, page 61).

Figs. 20A and 20B represent the trachoma prevalence rate of the various age groups expressed in the percentage of individuals examined and the relative proportion of Mac Callan's stages I to IV, expressed in the percentage of all cases of trachoma of the respective age groups resp. The pannus prevalence rate, expressed in the percentage of all individuals examined in the respective age groups, is represented by the dotted line in fig. 20A.

In all other areas screened, the trachoma prevalence curves show a more or less gradual and constant fall after the initial peak. In the Upper Digul area however, the initial marked fall is followed by a gradual rise (fig. 20A). The conditions which underlie this aberrant course of trachoma prevalence rates will be dealt with in the paragraph 'Epidemiological Considerations' on page 85.

SUMMARY:

Total number of individuals examined	1457
cases with trachoma	888 = 61%
cases with unilateral reduction of visual acuity as a result of trachoma	1
cases with bilateral reduction of visual acuity as a result of trachoma	0
blind by trachoma	0

An estimated 25% of the population of the villages in this region was examined.

The Tamrau Mountains

Trachoma in the Tamrau Mountain Range chiefly manifests itself as trachome pur. It is characterized by the almost invariable presence of follicles, both in the young and the old. This is shown by fig. 21B.

In 47% of the Trachoma I, II and III cases the follicular process extends onto the upper tarsus. The follicles invariably remain immature. Most commonly they are small, translucent and rather superficial, often arranged in parallel rows and surrounded by only slight conjunctival hyperaemia. In some cases they are somewhat larger, show a gelatinous aspect and occasionally tend to become confluent. The lower eyelid is generally a little more involved than the upper eyelid. In only a small percentage (fig. 21B), slight scar formation was noticed between the follicles, chiefly in the superior fornix. The hand slit-lamp here proved its value. Pannus was present in only 15% of

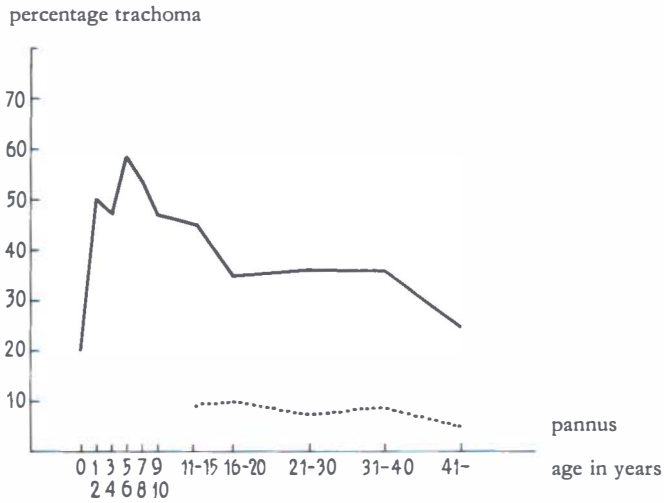


FIG. 21A - Prevalence rate of trachoma (all stages) according to age groups in Tamrau Mountain area
The dotted line represents the percentage of the population with pannus

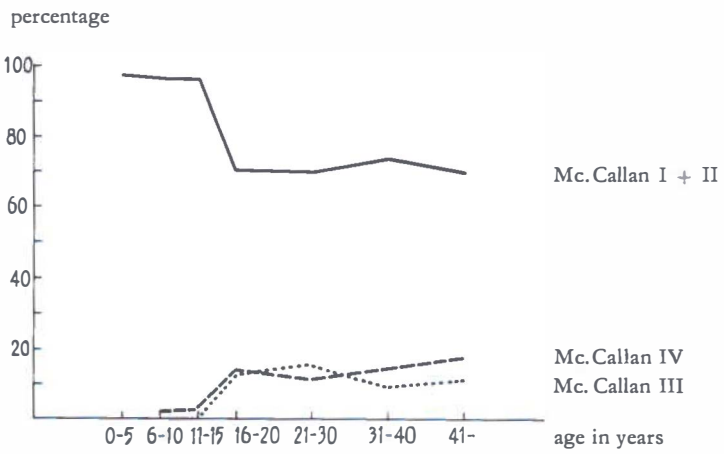


FIG. 21B - Relative proportion of stages Mac Callan I + II, III and IV according to age groups in Tamrau Mountain area

all trachoma cases. The maximal extension of the vascular infiltration was 2 mms.

The final diagnosis here was established only after examination of the conjunctival smears. Due to a technical mistake, only 28 from 58 smears were adequate for examination. Of these, 13 showed initial bodies. Since the smears were taken in too cautious a manner, they did not contain follicular material.

Because we were unable to examine more than 944 inhabitants of this rugged country and also because children were not so numerous as they were in other districts, the sub-groups below the 10th year comprise too few individuals for satisfactory statistical evaluation (average of 48 per group). This may explain the slightly irregular curve in fig. 21 A.

SUMMARY:

Total number of individuals examined	944
cases with trachoma	371 = 39%
cases with unilateral or bilateral reduction of visual acuity as a result of trachoma	0
blind by trachoma	0

An estimated 60% of all inhabitants of the area visited was examined.

The Schouten Islands

For the reasons given on page 4, only a pilot study was carried out in this area, based on 155 school children ranging in age from 7 to 14 years. In 85 children (55%) trachoma was found, often as the trachome mixte type. Pannus was present in 63% of the trachoma cases and varied from barely visible to a length of 4 mm. In no case did pannus reach the central corneal area. In 8 cases keratitis punctata was found without vascular infiltration of the cornea.

The Schouten Islands constitute the only area in Western New Guinea in which other workers have previously carried out systematic screening examinations for trachoma, in particular of school children (van Rhijn, Jansen, Löschdorfer).

Van Rhijn (1955) found trachoma in 43% of 683 school children.

District Medical Officer Jansen carried out an examination of a large number of unselected individuals during a mass treatment campaign against yaws in 1955. He noticed irreversible conditions, such as

scars, trichiasis and entropion (not specified) in 14.4% of all individuals over 45 years of age in the district Wardo (South-West Biak). Jansen, a general practitioner, could not definitely establish the diagnosis trachoma, because of the absence of pannus; he did not make use of an optical instrument. Neither were conjunctival smears made. He stressed that conjunctivitis and pterygium are of common occurrence.

Löschdorfer (1958), in Biak, found trachoma in 63% of 63 school children. The trachoma was of a mild type.

During regular visits to the hospitals of Biak and Manokwari in my capacity of Consultant Ophthalmologist, I saw many, chiefly elderly trachoma patients with serious complications such as trichiasis, entropion, symblepharon and pannus, covering the central corneal area.

My preliminary impressions lead me to believe that of all areas screened in Western New Guinea, the Schouten Islands merit the dubious distinction of harbouring the most severe type of trachoma.

AGE OF ONSET OF TRACHOMA

Considering that trachoma manifests its activity already at a very early age of the patients, much effort was made to screen these early age groups as fully as possible.

At first the difficulties encountered in this task threatened to defy the patience of the investigator, but the expert cooperation of the mantri, assisted if necessary, by interested onlookers, more often than not enabled me to complete the examination of the very young. In due course the necessary skill was acquired to make the undisturbed examination of a sleeping or suckling baby a normal procedure. Gradually the examination of babies and young infants became a question of routine hardly requiring more time than usual.

From the trachoma-prevalence curves shown in the preceding pages it follows that symptoms of trachoma were found in from 20 to 50% of all children up to 12 months of age in the various districts. Initially, immature follicles develop at about the same time in the medial or mesial part of the upper tarsal border of the upper eyelid and at the lateral side of the lower eyelid. In some cases the follicles develop gradually, the conjunctiva remaining otherwise normal except for a slight hyperaemic swelling in the diseased part.

In other cases an acute or chronic conjunctivitis concurrent with the

follicular process was noticed in children of a few months old; therefore the possibility of an acute onset of trachoma in some of the cases could not be excluded.

During the first few months of the survey, the ages below one year were not specified in weeks or months. Afterwards ages have been determined as accurately as possible.

In this way data on 170 babies from the Wissel Lake, Radja Ampat, Mimika and Upper-Digul districts became available, ranging in age from 1 day to 11 months.

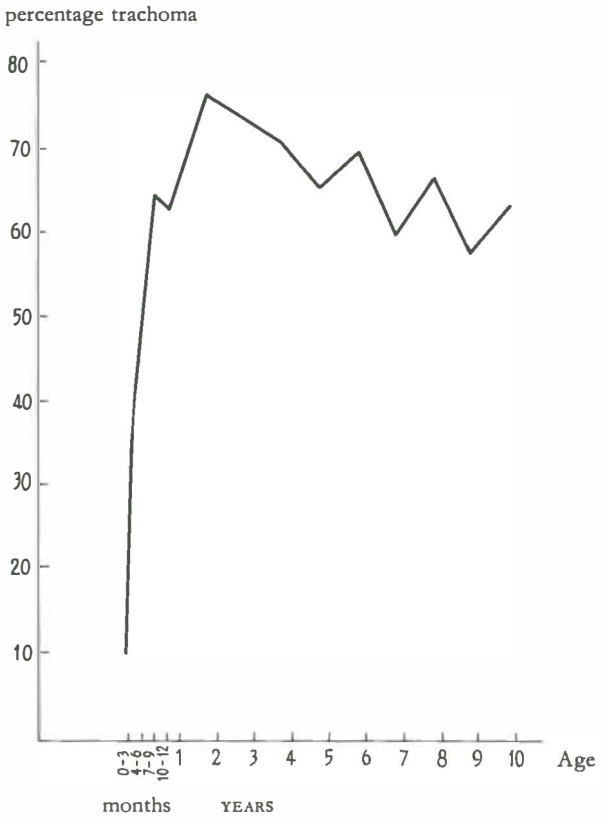


FIG. 22 - Prevalence rate of trachoma in children aged 0-10 years, with special reference to children below the age of 1 year, sampled from the areas Radja Ampat, Wissel Lakes, Mimika and Upper-Digul)

Number of children examined: 1971 Number with trachoma: 1268

This group was divided into the following 4 sub-groups.

age in months	number examined	cases with trachoma	percentage with trachoma
0-3	40	4	10
4-6	69	26	38
7-9	44	22	50
10-12	17	11	65

Granted that these sub-groups are not large, it will be clear from this table that typical trachomatous symptoms chiefly manifest themselves after the third month of life and that the frequency of trachoma increases sharply after this age. These data have been represented graphically in fig. 22. In addition, the trachoma-percentages of all children ranging in age from 1 to 10 years living in the same districts have been represented in this graph.
Figure 22 clearly shows that the peak prevalence is reached at the age of two: after this, the trachoma prevalence rate gradually decreases.

SEX DISTRIBUTION OF TRACHOMA

The trachoma prevalence rates in the six screened districts and analysed according to the sex of the individuals affected have been represented graphically in fig. 23. It will be seen that the prevalence rates are about the same for both sexes up to the 20th year, after which a consistently

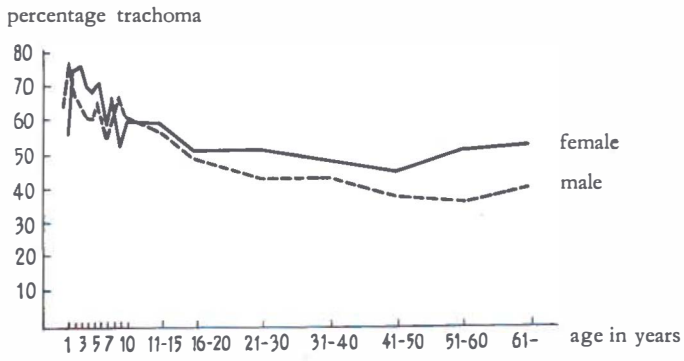


FIG. 23 - Prevalence rates of trachoma (all stages) in male and female according to age groups of six areas

Number of males examined : 4093 — Number with trachoma: 2126
Number of females examined: 3463 — Number with trachoma: 1924

FIG. 23A, B and C show the relative proportion of trachoma stages according to age and sex groups of six areas

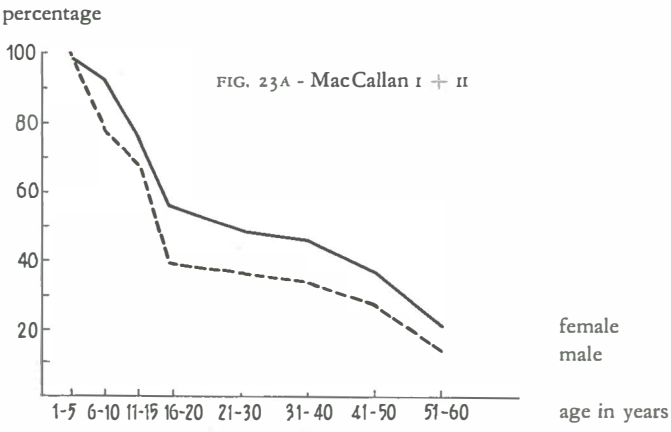


FIG. 23A - MacCallan I + II

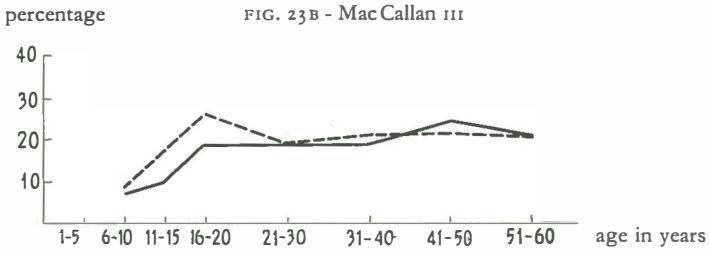


FIG. 23B - Mac Callan III

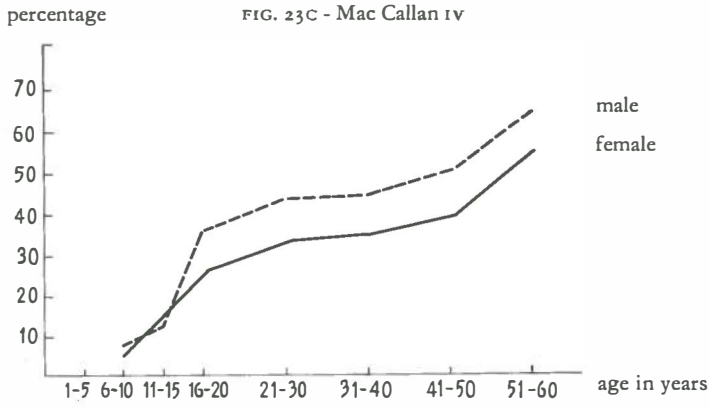


FIG. 23C - Mac Callan IV

higher rate is found for women of all age groups. When the relative proportion of trachoma stages Mac Callan I through IV and the sex distribution is plotted, the results clearly show a significantly higher rate for the active stages Mac Callan I and II in the case of females (figs. 23 A, 23 B and 23 C). The difference becomes striking when the females reach the reproductive age. A plausible explanation which immediately suggests itself is that the higher rate is caused by new infections from children, because the contacts between the mothers and children are much more intensive than those between the males and the young children.

The screening procedure did not allow determination of the sex of infants below one year of age. Very young infants in Western New Guinea are often carried in carrying nets, bundled up in a variety of cloths or leaves.

As rapid work was imperative no effort was made to determine the sex of the babies, as interrogation of the mother with the help of an interpreter was just as time consuming as unwrapping the children themselves. Therefore this age group has not been represented in figure 23.

TRACHOMATOUS PANNUS

The question whether the presence of pannus is essential for the diagnosis of trachoma is still undecided. Some workers deny this, others assert that in every case of trachoma formation of pannus will be found, be it that its development may vary within very wide margins indeed.

According to Mac Callan[46] 'vascular abnormality occurs at such an early date of the trachomatous invasion of the conjunctiva as to be of almost simultaneous occurrence.' Indeed, in experimental infections, pannus may already develop within one or two weeks (Mann et al. 1960, Mitsui et al. 1962).

Mitsui et al. point out, however, that pannus and epithelial keratitis do not invariably follow experimental infections and suggest that viral strain differences might explain this.

Lopes de Andrade and Pavković-Bugarski also believe that pannus does not develop in every case of trachoma.

Before the Second World War trachoma still occurred in the Netherlands, chiefly in Amsterdam, in a mild form characterized by follicles which were localized predominantly in the fornices. In a large number of cases, when examined with the slit-lamp microscope

by prominent Dutch ophthalmologists such as Zeeman, Straub and Mulock Houwer, no pannus formation was reported.[58]

In Japan, Suzuku examined with the slit-lamp schoolchildren with trachoma. He found pannus in only one third of the cases. Mitsui (1955) found a microscopical pannus in only 60% of schoolchildren with confirmed trachoma (presence of inclusion bodies).

In Taiwan serological studies have provided evidence that many children have trachoma who have been diagnosed as having non-trachomatous follicular conjunctivitis, usually because no corneal disease was found (Grayston et al. 1962).

The occurrence of pannus in trachoma in Western New Guinea

During the screening survey of the population of Western New Guinea, great attention was paid to the limbal vessels. The vessels of the normal limbus may show wide variations in shape and course. A single dip of a vascular loop into a clear cornea does not constitute a pathological phenomenon and certainly in countries in which trachoma is endemic, should not be interpreted as evidence of pannus.

In this context, it is appropriate to cite Ching (1954) who remarked: 'the observer must be careful to differentiate what is normal limbus from what is pannus, as the demarcation is not always a sharp one.' Neither should Millet's lunula (the wide overlap of the sclera at the upper corneal limbus), which also in Papuans is frequently found, be interpreted as a sign of trachoma.

In the present series, pannus was diagnosed only when the end-capillary loops clearly interrupted the regular pattern of the limbal vascular loops and extended into the cornea, be it only over a minimal distance.

In some cases perivascular infiltration of limbal vessels could be observed before vascular infiltration into the cornea had started. Neither these cases nor those of keratitis punctata were included in the figs. 16A, 18A, 19A, 20A and 21A; in the latter only the cases with corneal vascular infiltration are represented.

The diagnosis of a pannus of only 1 to 2 millimetres in length even when in the inactive stage, usually is quite feasible with the hand slit-lamp, in particular when retro-illumination is used. In contrast to this, the diagnosis of incipient pannus formation, as evidenced by the slight dilatation of terminal limbal vascular loops or by the very slight

perivascular infiltration, occasionally is possible only under optimal conditions, such as the dark room and the slit-lamp microscope.

In view of these considerations the percentages of pannus as found during the survey and represented in the graphs will actually be higher. In figs. 16 A and 18 A the pannus prevalence rates show an unmistakable tendency to decrease in the more advanced age groups. This in itself indicates that the diagnosis in a certain percentage of cases has been missed, because corneal vascular infiltration is anatomically irreversible and always leaves ghost-vessels at least. This will chiefly concern very small, inactive pannus.

On the other hand, fig. 16 A shows that an existing high percentage of pannus may indeed be diagnosed. Here again it chiefly concerns small pannus, in an active stage however, of the type frequently encounterd in young infants.

All this is highly suggestive for the conclusion that the differences between the pannus prevalence rates as found in the various districts (see table 1 page 61) in general reflect existing conditions.

For instance, an area showing a very low pannus prevalence rate are the Wissel Lakes. The absence of secondary infections – the majority of cases are of the trachome pur type – allowed a dependable diagnosis of changes of the limbal vessels to be made. The limbus in the large majority of cases proved to be completely normal, without irregularity of the terminal vascular loops, without hyperaemia or perivascular infiltration. Punctate keratitis was seen only a few times.

A very common type of trachoma, as observed in the Wissel Lake area for instance, is represented in Plates I through IV (pages 42 and 43).

For that matter, the discussion in the preceding pages clearly shows the minor clinical importance of pannus in the areas visited. The graphs of other areas also show a low pannus prevalence rate, although less marked than that of the Wissel Lakes. Comparison of the graphs of the areas Sentani and Radja Ampat (fig. 16 A and 19 A) shows that the date of onset of pannus is not the same in all areas but may range from a short period up to several years after the infection.

Comparison of all areas shows the presence of a certain correlation between the percentage of active trachoma cases with follicular involvement of the tarsus and the percentage of trachoma cases with pannus, as expressed in percentages of the total figure of trachoma cases. This is presented in table 1.

TABLE 1 - Frequency of some characteristics of trachoma in six New Guinea regions

Region	average trachoma prevalence (%)	active trachoma cases with tarsal follicles (%)	trachoma cases with pannus (%)
Wissel Lakes	62	35	0.3
Tamrau	39	47	16
Mimika	38	57	14
Upper-Digul	61	62	11
Radja Ampat	67	63	38
Sentani	51	86	68

Conclusion

The symptom of pannus formation is an important, but not an essential symptom for the diagnosis of trachoma, for pannus may be absent in the natural history of trachoma in many cases indeed.

CYTOLOGY OF CONJUNCTIVAL SMEARS

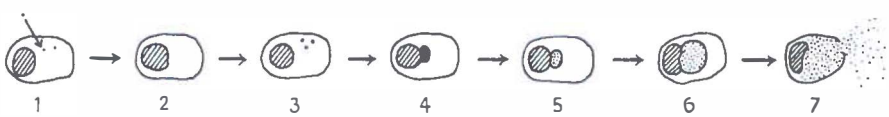
In this paragraph the results of the histological examination of conjunctival smears will be dealt with. In the areas screened usable conjunctival smears were obtained from 302 individuals. The smears were taken for purposes of diagnosis mainly and therefore mostly concerned cases of the follicular stages without pannus or scar formation.

To check on controversial epidemiological questions which arose during the survey, smears were obtained also from individuals without trachomatous symptoms and from cases of clinically healed trachoma in later and final stages of the survey. This was carried out for the first time in the Wissel Lake and Mimika areas on individuals without manifest trachoma, in each area in two instances. Because three out of four smears were clearly positive for inclusion bodies, this type of examination was continued on a larger scale during the survey of the next and last investigated district (the Upper-Digul area).

Some cytological changes resulting from cell-necrosis as commonly seen in smears from cases of trachoma have already been discussed on page 34.

The intracellular inclusion bodies may be present in several forms, depending on the stage of the developmental cycle of the virus. This cycle was described for the first time by Lindner (1910). The light-microscope reveals the following: First there are one or more small initial bodies, rounded or oval in shape, visible in the cytoplasm; staining dark blue with the Giemsa stain. The next stage is an increase in size and number and coalescence to virus colonies of widely divergent shapes and sizes. These colonies are mostly situated close to the cellular nucleus and are called inclusion bodies. Their component particles range in size from 0.3 to 1.2 μ (Thygeson, 1959). In the subsequent stage the initial bodies gradually disappear to be replaced by smaller corpuscles, called elementary bodies, which are about 0.25 μ in size and assume a red colour in the Giemsa stain. The elementary body inclusion body subsequently and gradually may increase in size to such an extent that all of the cytoplasm becomes replaced by it: in this state it is called mature elementary body inclusion body. If the epithelial cell, because of this process, bursts, its contents are spilled out and the elementary bodies are set free. Initial bodies may also be encountered freely in the extracellular space (Lindner[40]). Dark (1955) finally stressed that many intermediate forms occur, such as for instance small inclusions consisting of elementary bodies and large ones consisting of initial bodies.

The life cycle of the trachoma agent is represented schematically in the diagrams below



1. Elementary body, entering epithelial cell
2. "Dark period" in which elementary body disappears
3. Initial bodies appear in the cytoplasm
4. Initial bodies grow until they form an initial body inclusion body
5. Initial bodies are replaced by elementary bodies
6. Nearly mature elementary body inclusion body
7. Epithelial cell bursts. The elementary bodies are set free

The group of 302 smears is to be analysed as follows:

A. 191 smears of exclusively follicular cases, ranging in age from 2 to 50 years. This sub-group comprises the follicles of any aspect such as have been described in the sections on various districts.

B. 44 smears from cases with active trachoma showing more than one symptom. They ranged in age from 7 to 45 years.

C. 22 smears from individuals with healed trachoma, ranging in age from 10 to 45 years. For the criteria of healed trachoma see page 00.

D. 30 smears from cases with slight papillary hypertrophy only, ranging in age from 6 to 41 years. This sub-group comprises both cases with papillary hypertrophy localized only at the upper tarsal border and cases with more wide-spread papillary hypertrophy.

E. 15 smears form individuals with normal eyes, between the ages of 17 and 38. Of these 13 came from the Upper-Digul area.

In most areas of Western New Guinea one hardly ever encounters a native whose conjunctivae are without any sign of irritation (page 35). Because of this, group E comprises in addition to individuals with completely normal eyes, persons whose conjunctivae showed symptoms of irritation which were so slight as to be considered within normal limits.

ad A. The findings obtained in the 191 smears of group A (follicles only) were as follows:

negative	55
positive for inclusions	96
positive for inclusions and Leber cells	19
positive for Leber cells	21

Positive for inclusions: 115 = 60%

ad B. The 44 smears of group B (active trachoma with more than one symptom) were divided as follows:

negative	15
positive for inclusions	25
positive for inclusions and Leber cells	2
positive for Leber cells	2

Positive for inclusions: 27 = 61%

ad C. Of the 22 smears of group C (healed trachoma) were:

negative	3
positive for inclusions	19 (of which 5 strongly positive)

Positive for inclusions: 19 = 86%

ad D. The analysis of the findings in the 30 smears from group D (slight papillary hypertrophy only) yielded the following figures

negative	17	
positive for inclusions	12	(of which 2 strongly positive)
positive for Leber cells	1	

Positive for inclusions 12 = 40%:

ad E. The 15 smears of group E (normal or practically normal eyes) was:

negative	6	
positive for inclusions	9	(of which one strongly positive)

Positive for inclusions: 9 = 60%

Total figure of smears positive for inclusions: 182 = 60%

No correlation could be found between the extent of the trachomatous process and the quantity of inclusions in the conjunctival smears in this series of patients. For instance strongly positive smears were obtained from cases with only slight trachomatous symptoms (such as for instance the presence of only a few follicles) or even without characteristic trachomatous symptoms, only showing slight papillary hypertrophy. And one strongly positive smear was even obtained from an individual with normal eyes. Comment should be made here, that we are dealing with normal eyes from areas in which trachoma is highly endemic.

In the course of two years, I carried out a check on the findings set out above, in obtaining numerous smears from normal eyes of Europeans who visited the Central Hospital at Hollandia for refraction anomalies. In not a single 'European smear' were inclusions found.

To the best of my knowledge only a few communications in the literature maintain that virus carriers* do occur.

Bodian (1947) reported a high prevalence of virus carriers in the Fiji Islands. In 34.6% of 78 natives who showed no evidence of clinical trachoma the conjunctival scrapings revealed the presence of inclusion bodies. The excellent microphotographs in his paper leave little doubt concerning the authenticity of the initial body inclusions. According to Swanston, however, this could be explained by the fact that the clinical examinations of Bodian were carried out with low magnification (condensing lens and a loupe with magnification $2\frac{1}{2}$), in this way certainly missing some minor cases of trachoma.

* A (healthy) carrier is an individual harbouring a pathogenetic microorganism, without showing clinical signs and symptoms of it.

Sysoyev (1960) in a survey of trachoma-infested areas in Russia found the conjunctival smears to contain inclusions in 1% of clinically healthy individuals.

My own findings do not corroborate Thygeson's assertion that 'so far no evidence to indicate the existence of a sublinical infection or carrierstate has been advanced.'[86]

My findings definitely indicate that virus carriers in trachoma-endemic areas do occur.

The evaluation of the smears, all of which had been stained according to Giemsa May-Grünwald's method, was based upon strict criteria in order to avoid erroneous interpretation. Correct interpretation requires dependable staining methods, careful work and experience. For instance, initial bodies may be mistaken for pigment granules. In the Giemsa stain however, the latter assume a blue-green or greenish colour. Inclusion bodies may be confused with extruded nuclear material and cellular debris. As Thygeson stresses in a personal communication on elementary bodies,' 'only a clear-cut inclusion body in which individual elementary bodies can be seen is diagnostic.' Finally, since free elementary bodies can only with difficulty be differentiated with any degree of certainty from cellular debris, they were not diagnosed by the present author.

Elementary body inclusions which met the criteria exposed above were diagnosed in only 6 instances, so that the diagnosis in the remaining 176 smears was made on the presence of initial bodies. Microphotographs of some smears are represented in figs. 24 through 29, (p. 67, 68, 69).

All smears were fully examined; particularly those containing an abundance of cellular material were examined with great care. This procedure was most rewarding since in many instances positive cells were found only after extensive searching.

In general abundant material was obtained as scraping of the conjunctivae was done vigorously. Only in one of the first areas visited (the Tamrau Mountains) scraping was performed too cautiously, with the consequence that only 46% of the smears obtained were positive for inclusions. This group has been included in the 302 smears.

When one considers that, in spite of both the non-optimal method of virus tracing (conjunctival smears) and the frequently adverse conditions under which the procedure was carried out, an average of

60% of all smears revealed inclusions, it will be clear that the real percentage of virus circulating among the population must be higher. According to Collier (1960) the method of virus isolation yields a figure of positive cases which is about 50% higher than that obtained by collecting smears. Sowa and Collier (1960) in West Africa reported 30% higher findings by means of the virus isolation method.

If these data are transposed to the findings of the present survey, such a comparison would suggest a real virus prevalence of over 90% of the population. This means that the Western New Guinea milieu is nearly totally infected. Conclusive proof for this assumption can only be given by a virus sample survey.

Conclusions:

- In all stages of trachoma a relatively high percentage of inclusions (an average of 60%) was found in conjunctival smears.
- In the large majority of smears the diagnosis was based on the presence of initial bodies.
- In view of the cytological findings, a large number of cases of papillary hypertrophy in children and adults, in particular when localized along the upper tarsal border, in areas where trachoma is highly endemic, should be regarded as being trachomatous.
- The carrier state (i.e. the existence of subclinical infection*) in trachoma has been shown to be real. In highly endemic areas the existence of healthy trachoma virus carriers not only is a fact but is also much more frequent than has been believed hitherto.

* A subclinical infection is an infection which is below the threshold of clinical recognition.

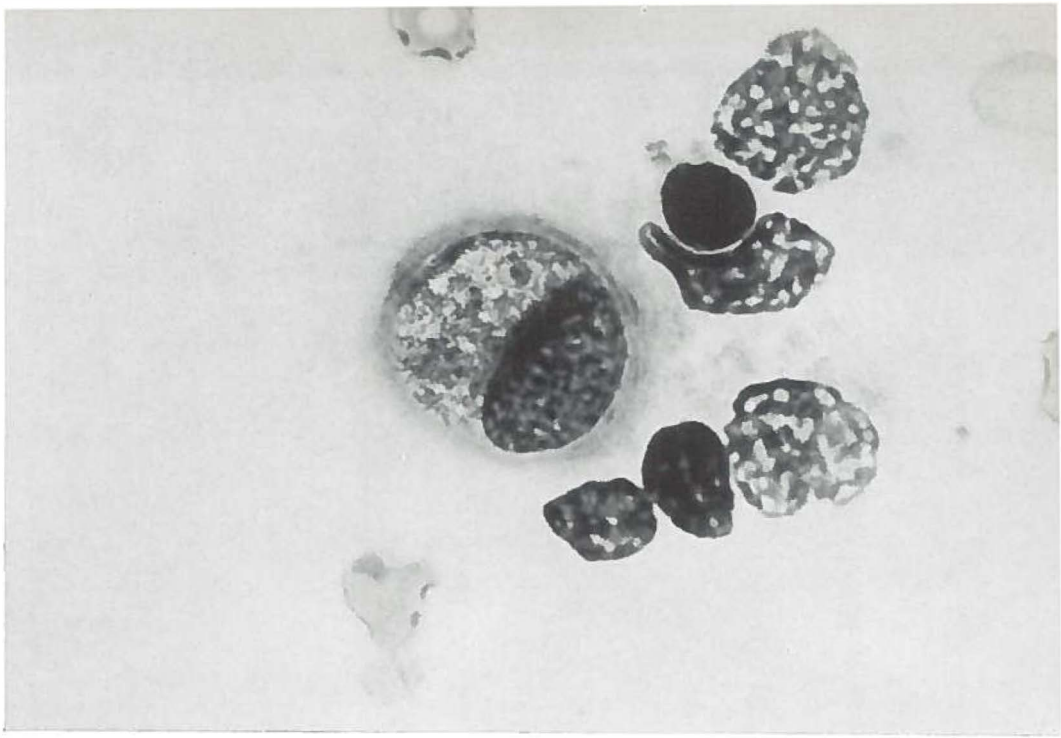
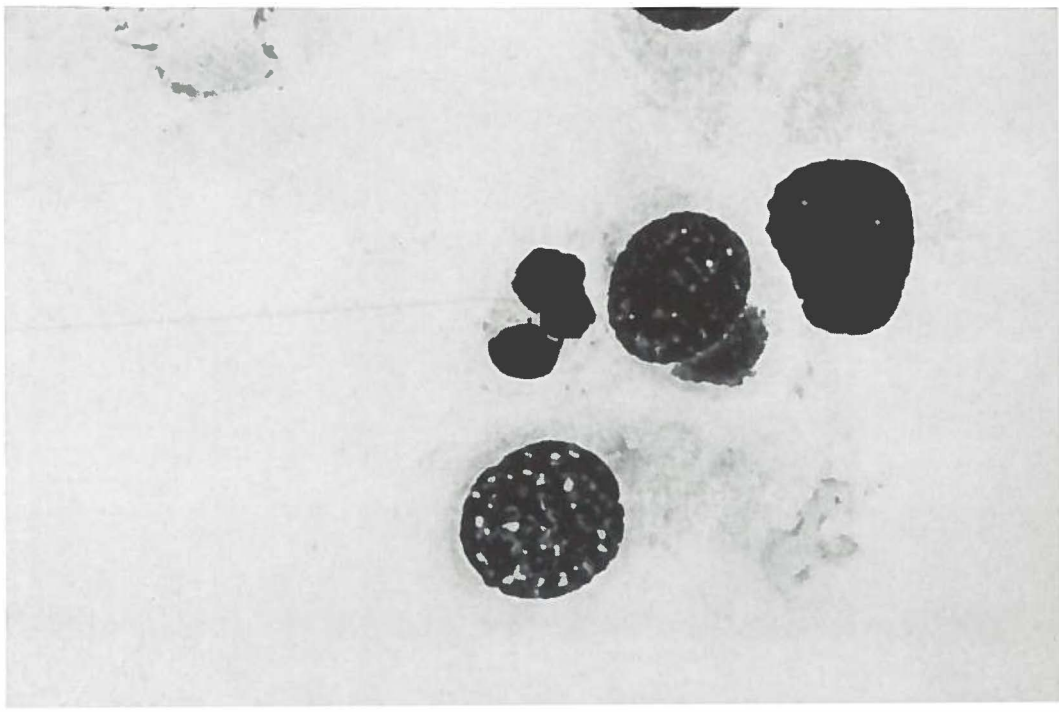


FIG. 24 - Nearly mature elementary body inclusion body. Nucleus and inclusion body are surrounded by a narrow zone of cytoplasm. Giemsa May-Grünwald Stain. × 1650

FIG. 25 - Conjunctival epithelial cell with bonnet shaped inclusion body. Cell at the left is polymorphonuclear leucocyte. Giemsa May-Grünwald Stain. × 1650



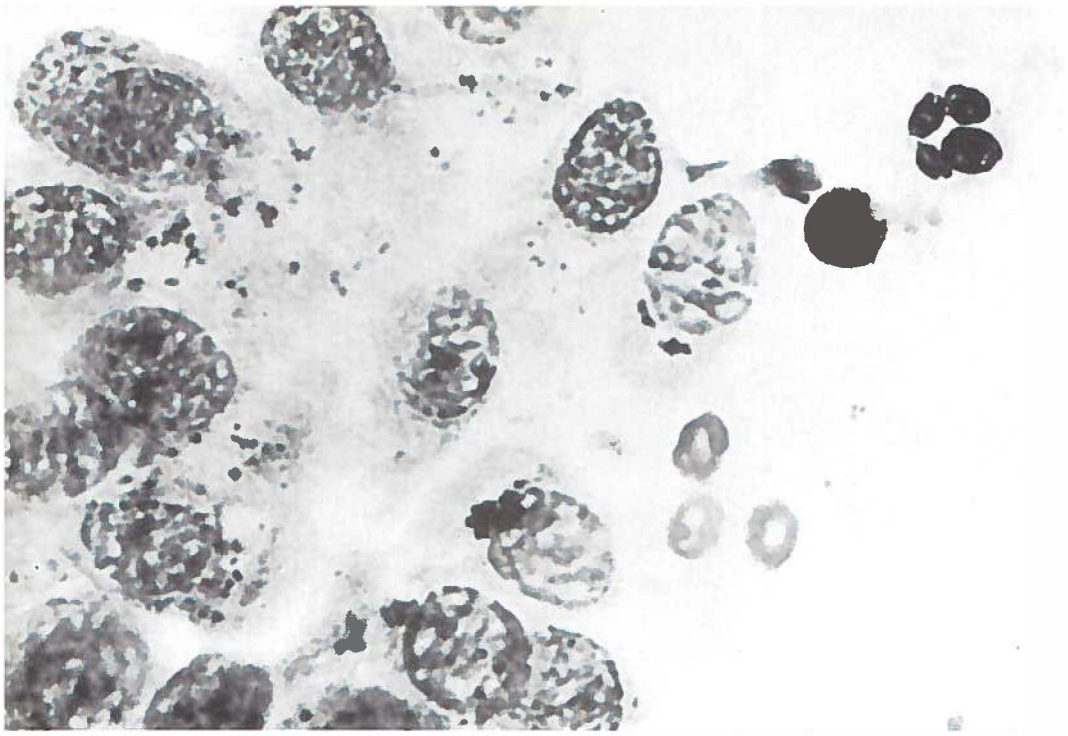
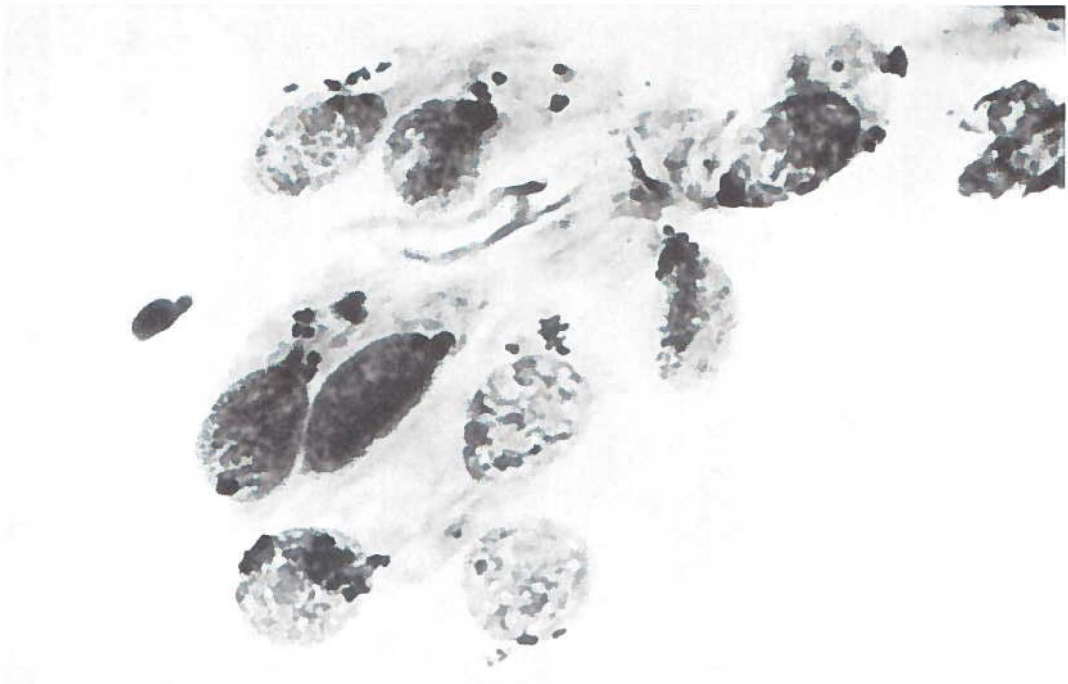


FIG. 26 - Conjunctival epithelial cells with smaller and larger initial bodies. Male, 34 years. Normal conjunctiva and normal cornea. Giemsa May-Grünwald Stain. × 1650

FIG. 27 - Conjunctival epithelial cells with smaller and larger initial bodies. Case of Trachoma I-II. Female, aged six. Small, transparent follicles in upper fornix and immature follicles on tarsal conjunctiva. In lower eyelid small yellowish follicles are present. Pannus is absent. Giemsa May-Grünwald Stain. × 1650



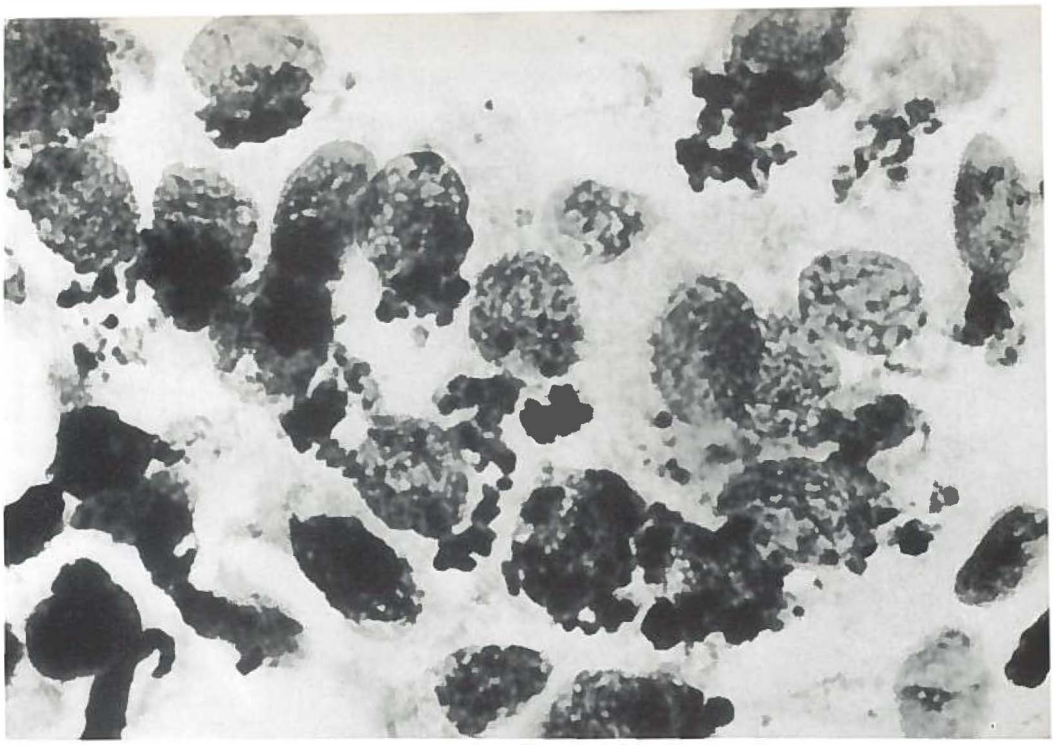
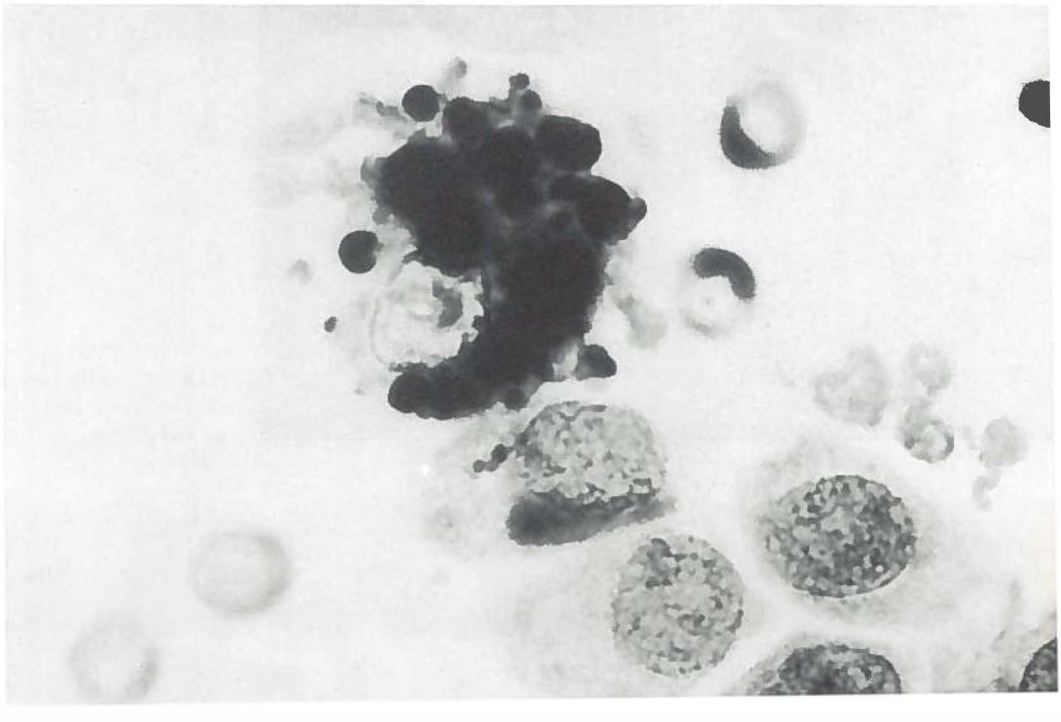


FIG. 28 - Conjunctival epithelial cells with huge conglomerations of large initial bodies. All dark parts of photograph are entirely made up of initial bodies. Case of Trachoma IV. Male, 51 years, showing slight scar formation in upper fornix, with concrements and cysts in between. Slight papillary hypertrophy. Pannus is absent. Giemsa May-Grünwald Stain. × 1650

FIG. 29 - Macrophage (Leber cell) containing cell debris, surrounded by conjunctival epithelial cells and erythrocytes. Note deformed nucleus. Giemsa May-Grünwald Stain. × 1650



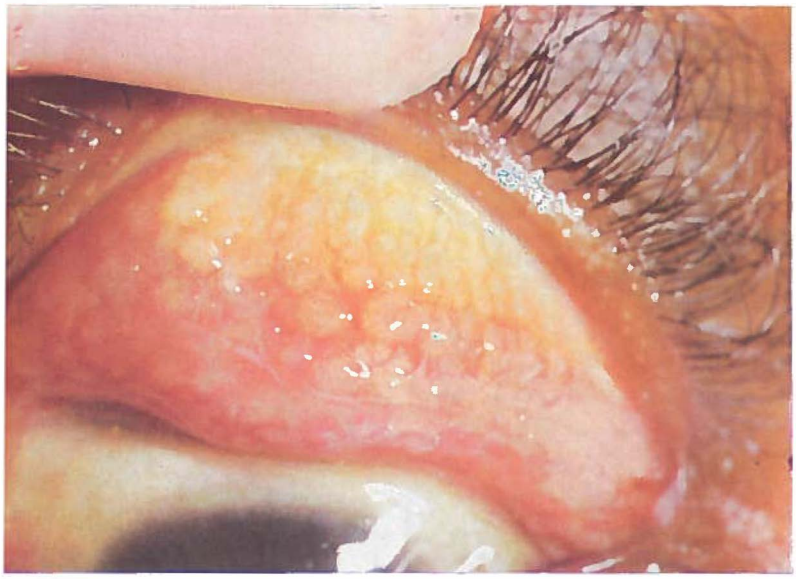


PLATE V - Trachoma I-II, resembling folliculosis-like condition. Part of the upper fornix shows yellow follicles located mainly along the upper tarsal border and adjacent supratarsal conjunctiva. Immature follicles are present on tarsal surface. Peri-follicular hypertrophy is only slight. White irregular line, traversing the follicles is not scar tissue, but deep lying, normal conjunctiva. Pannus is absent. (Case of 8 year old boy).

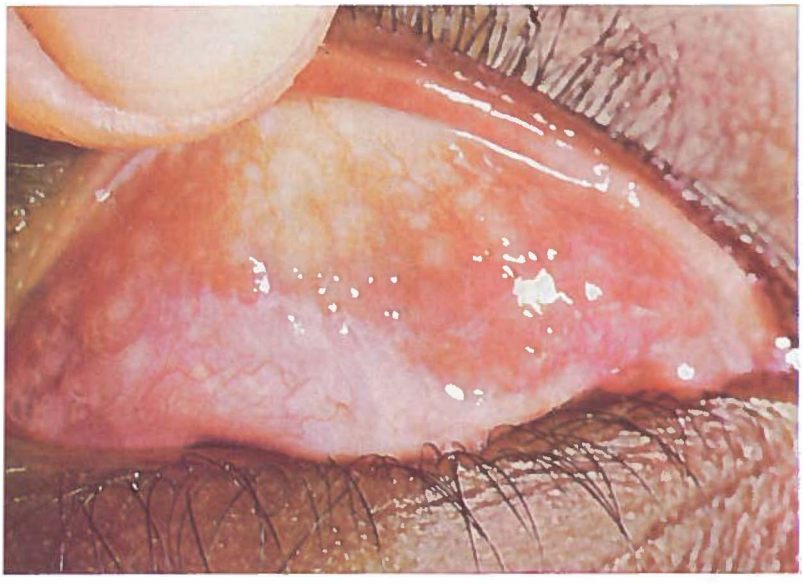


PLATE VI - Other eye of case of Plate V. In the supratarsal conjunctiva a sheet of fibrous tissue is present.

THE DIFFERENTIAL DIAGNOSIS OF FOLLICULOSIS

The type of trachoma as has been described in the previous pages apparently is a process which often does not involve the tarsal conjunctiva and often is not associated with pannus (see table 1 page 61) Because of this, the condition might easily be confused with Folliculosis (for description of folliculosis see page 33). The insufficiency of the clinical picture to decide the question of differential diagnosis has also been demonstrated by the serological investigations of Grayston et al. (1960) carried out in Taiwan. These provided evidence that many children have trachoma infections who have been diagnosed as having non-trachomatous chronic conjunctivitis or folliculosis, usually because no corneal disease was found.

The importance of this, however, is evidenced by the fact that in some areas with typical trachoma, such as for instance the village of Fanfanlap on the Island Misoöl, the clinical aspect of the follicles also in older individuals can hardly be distinguished from those in folliculosis or not at all. Folliculosis was diagnosed only seven times.

During field work correct diagnosis in all cases is an unattainable ideal. Undoubtedly some cases of folliculosis will have been diagnosed as trachoma; their number in proportion to the total number of cases diagnosed as trachoma will probably be negligeable, however. Such a view is supported by the results of the screening survey carried out by Mann and Löschdorfer (1955) in the Territories of Papua and New Guinea. They stated that only in 225 out of 13,717 instances the diagnosis of 'follicular reaction other than trachoma' had been made, i.e. in about 1.6% of the cases.

The set-up of our survey in Western New Guinea was chosen so as to assess the findings in any individual case against the back-ground of family and kampong. This must have contributed towards a more correct evaluation of the anomalies observed.

However, granted that incorrect diagnosis in some instances may have been made, the fundamental conclusions derived from the figures presented in the preceding graphs and pages, will not be invalidated. In particular the conclusions concerning the percentage of spontaneous healing and the differences in healing tendency between various areas will not be vitiated, since these have been calculated from the differences between maximum and minimum trachoma prevalence, both of which concern age groups in which folliculosis hardly occurs.

THE TENDENCY TO SPONTANEOUS CURE OF TRACHOMA AND FIGURES CONCERNING THIS PHENOMENON

As will be evident from the figs. 16A to 21A the relation between trachoma prevalence rates and age groups in all regions without exception shows the same characteristics, viz. a marked increase of prevalence in the first twelve months of life, a peak prevalence which is reached within the first few years of life, followed by a decrease which is steepest before the age of 20.

The figures 16A to 21A lead one to infer that in all districts a certain number of spontaneous cures which leave no sequelae do occur.

For instance:

In the Mimika region a peak prevalence of 63% is reached in the age group of 1-2 years. After this age the prevalence drops more or less gradually until in the age group of 16 to 20 years the prevalence is 30% while in the age group of 41 to 50 years this prevalence is only 20%.

In other words: in a non-selected group of the Mimika region which has a trachoma prevalence of 63% in the young ages, this prevalence will drop with advancing age, having reached a value of 20% when this group has reached the age of 41 to 50 years.

This means that the original prevalence of 63% with advancing age has decreased down to 20%, which implies that a certain percentage of spontaneous cures have occurred which have left no trace. A calculation of this percentage follows.

From the nature of the curves 16A to 21A it will be clear that in general with the advancement of age, the number of healed trachoma cases will increase. For instance in the Mimika area 52.4% of the original trachoma cases, as represented by the maximum prevalence group, have healed without leaving traces when the age of 16 to 20 years is reached,

whereas this percentage in the age group of 41 to 50 years is 68.2%.

The age group of 41 to 50 years also contains a certain number of trachoma cases which have healed leaving sequelae (Trachoma IV cases). This percentage of Trachoma IV cases (also expressed as a percentage of maximal prevalence) must be added to the percentage of cases which have healed without leaving traces in order to obtain the percentage of *all* spontaneous cures, which have occurred in the age group of 41 to 50 years. For the Mimika region this total percentage of spontaneous cures is 79%*.

In this paragraph the tendency to spontaneous healing of trachoma in the various areas will be compared. It will be clear that for a uniform comparison of the healing tendency, the maximal prevalence of the different areas under consideration must be compared with the same more advanced age group. This group of the more advanced ages will be called the 'minimum prevalence' group.

For this 'minimum prevalence' group is taken, more or less arbitrarily, the age group of 41 to 50 years, because this age group is still sufficiently large in most of the areas investigated. An exception must be made for the Wissel Lake area, where this age group is practically extinct. Here the age group of 31 years and over was chosen instead.

This method of calculating spontaneous cures by comparing prevalence rates of different age groups, is only acceptable on certain conditions which will be treated on page 74.

* Example:

The percentage of spontaneous cures without sequelae and the percentage of all spontaneous cures for the Mimika area is calculated as follows:
Maximal trachoma prevalence rate = 63% (Addendum, table 15). The trachoma prevalence in age group 41 to 50 years = 20% (Addendum, table 15). The difference, representing the spontaneous cures without sequelae = 43%. Expressed in percentage of maximal prevalence this is 43 : 0,63 = 68,2%.
In other words: 68,2% of the trachoma cases heal without leaving a trace.
The percentage of total spontaneous cures (percentage without leaving traces added to the percentage of Trachoma IV cases) is calculated as follows:
In the age group of 41 to 50 years the trachoma prevalence is 20%. This group with trachoma consists of 35 people of which 12 have Trachoma IV (Addendum, table 15). The percentage Trachoma IV in this age group is 12/35 × 20% = 6,8%. Expressed in percentage of maximal prevalence this is 6,8 : 0,63 = 10,8%.
The percentage of all spontaneous cures is 68,2 + 10,8 = 79%.
This means that 79% of the trachoma cases heal spontaneously in the Mimika region.

As a matter of fact, the calculated percentage of spontaneous cures without sequelae should be regarded as a MINIMUM percentage, because the 'minimum prevalence' group is likely to contain an unknown number of diagnosable reinfections, whereas the individuals of the age group showing maximul prevalence are too young to have acquired reinfections.

From the graphs 16A to 21A it can be calculated that the percentage of trachoma, healed without leaving sequelae, ranges from minimal 25,9 to 68,2% of the area under consideration (expressed as a percentage of the maximal prevalence). The minimum percentage of *all* spontaneous cures ranges from 64,5 to 79%. It is apparently independent of the average trachoma prevalence.

Table 2 shows the percentages of spontaneous cures in five New Guinea regions.

TABLE 2 - Percentage of spontaneous cures in 5 New Guinea regions

Region	average trachoma prevalence (%)	cures without sequelae (%)	cures with sequelae (%)	total percentage of spontaneous cures
Radja Ampat	67	25,9	46,3	72,2
Wissel Lakes	62	27,2	43,9	71,1
Sentani Lake	51	47	27,2	74,2
Tamrau Mts.	39	56,9	7,6	64,5
Mimika	38	68,2	10,8	79

The data from the Upper-Digul region have not been included in the table, because the prevalence curve of this area is markedly different from the other areas as it does not reflect the natural course of trachoma. This will be discussed on page 87.

The calculation of the percentage of spontaneous healing by comparing the prevalence in different age groups, assuming that the trachoma prevalence curves represent the natural course of trachoma, is valid on the following conditions:

1. that in the areas screened environmental and living conditions have remained unchanged for long periods of time.
2. that no trachoma has been introduced recently into virginal country.
3. that in the last 50 years no spontaneous change in prevalence has occurred.
4. that trachoma does not influence mortality.
5. that no general therapeutic measures have been taken.

ad 1. In spite of the recent increase of contacts of several regions with the outside world, no fundamental changes in living conditions have occurred in most of the areas

investigated. For an area in which these conditions have changed indeed the consequences will be discussed in the paragraph 'Epidemiological Considerations.'

ad 2. The regular course of the curves in figs. 16 to 21 A and B (with the exception of the Upper-Digul area) does not suggest a recent introduction of trachoma in Western New Guinea. This is confirmed by a comparison of the curves of an isolated area, like the Wissel Lakes (of which the inhabitants are still living in the Stone Age) with those of an area of which the inhabitants are a sea-faring people, which have had intensive contacts for many centuries with other countries, such as East Indonesia (Radja Ampat area). In both areas, the course of trachoma, as expressed in prevalence and in stages, is nearly the same, as comparison of figs. 17 A and B and 19 A and B shows. This supports the opinion that the curves represent the natural, undisturbed course of trachoma.

ad 3. Nothing is known about the trachoma prevalence in earlier times, for no large scale investigation was carried out prior to mine.

No data are available about possible spontaneous changes in prevalence of trachoma during the last 50 years in parts of the world (see also page 84). As the trachoma prevalence curves in every region of Western New Guinea show the most rapid decrease before the age of 20, this period of 50 years may be considered rather theoretical, it being shorter in actual fact. If, for some reason, a spontaneous change in prevalence has occurred in a large area, like the whole micro-continent of New Guinea, this, of course, would not account for the differences in the course of trachoma prevalence curves between the various areas.

As trachoma is a disease leaving only a relative and temporary immunity, the author feels that a spontaneous change of prevalence within a few decades is unlikely in a large endemic milieu.

It goes without saying that a decline in prevalence in areas where living and hygienic conditions have been improved and medical treatment has taken place, is to be considered as a secondary phenomenon, and not a spontaneous change in prevalence.

ad 4. It is due to the clinical nature of trachoma in Western New Guinea that it does not, directly or indirectly, influence the mortality rate.

ad 5. In Western New Guinea no large scale treatment was undertaken.

At first glance there seem to be striking differences between the curves of the figures 16 to 21 A and B. It is, however, only one detail on which these differences are mainly based.

This can be illustrated, for instance, by superimposing the three apparently very diverging curves of the Radja Ampat (highest average trachoma prevalence), Mimika (lowest average trachoma prevalence) and the intermediary curve of Sentani Lake (fig. 30, page 76).

A further analysis of this is given by fig. 30 A, in which the curves of the stages Mac Callan I + II found in the population of the same areas

(see figs. 19B, 18B and 16B) have been superimposed; the curves now are based on percentages of all individuals examined of the particular age groups.

Fig. 30A clearly shows that the prevalence rates of the stages Mac Callan I + II run a parallel course in the various areas; the active stages Mac Callan I + II disappearing to a practically similar degree and within a practically identical course of time.

The marked differences between the course of the trachoma prevalence curves in the different areas is explained satisfactorily by the observation that in one area in a large percentage of cases the follicles disappear without leaving a trace, whereas in an other area the follicles after a similar period of time, leave scars, or is pannus left. In order to show this graphically the stages Mac Callan III and IV (previously represented in the figures 19B, 18B and 16B, but now based on the percentage of all individuals examined of the particular age groups) have been planned for the same areas and represented in the figs. 30B and 30C.

In principle, this comparison also holds true for the other areas as shown in figs. 31, 31A, 31B and 31C (p. 78 and 79) in which both the

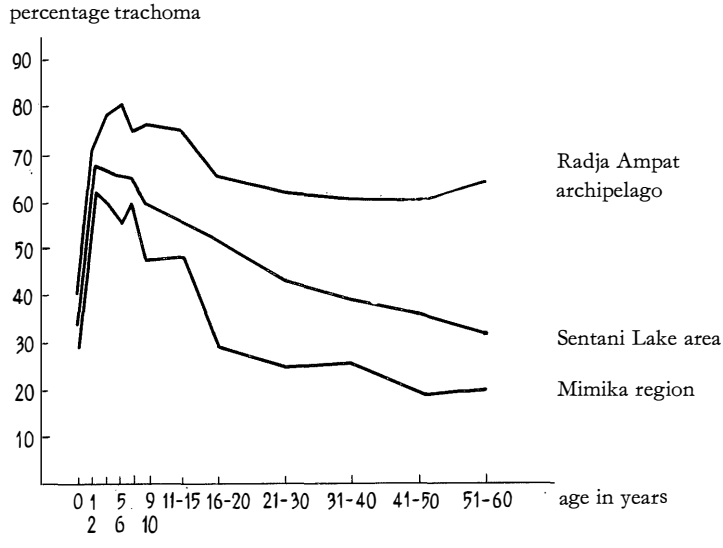


FIG. 30 - Superimposition of the trachoma prevalence curves of the Radja Ampat, Sentani and Mimika areas. (figs. 19A, 16A and 18A) The curves are apparently very diverging.

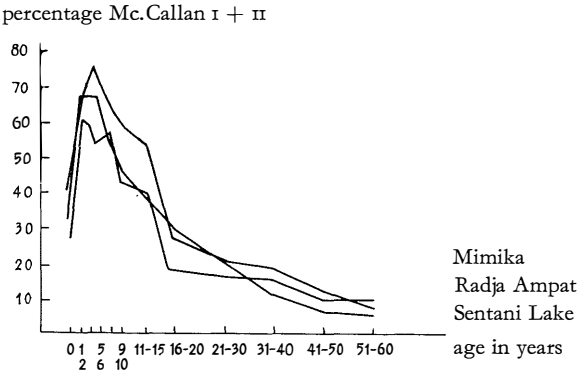


FIG. 30A - Superimposition of Trachoma I + II prevalences of Radja Ampat, Sentani and Mimika areas previously represented in the figures 19B, 16B and 18B. The curves now are based on percentages of all individuals examined in the particular age groups. The active stages I + II disappear in a practically identical way and in about the same period of time

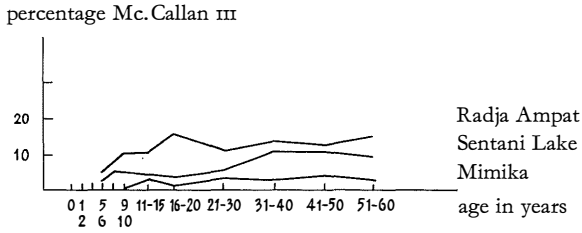


FIG. 30B - Superimposition of Trachoma III prevalences of the same three areas also expressed in percentages of all individuals examined in the particular age groups. There is only a minor difference between the various areas

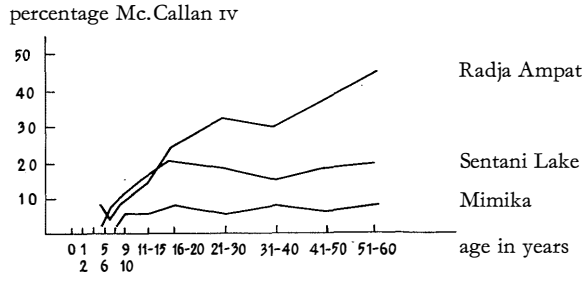


FIG. 30C - Superimposition of Trachoma IV prevalences of the same three areas, expressed in percentages of all individuals examined in the particular age groups.

The great differences between the trachoma prevalence curves of these areas (fig. 30) are largely determined by the different course of the Trachoma IV prevalence rates

trachoma prevalence curves and the curves of the various trachoma stages have been plotted in the same manner for the Wissel Lake, Tamrau and Upper-Digul regions.

Fig. 31 A shows that the trachoma I + II prevalence in the advanced age groups of the Tamrau and Upper-Digul population remains on a higher level. This will be discussed later (p. 87).

All curves show that trachoma develops its highest activity before the age of 20. The decrease of the Trachoma I + II prevalence is maximal in this period. The same holds true for the increase in Trachoma IV prevalence which in some areas has already reached its peak at the age of 20.

The fact that in all areas, in spite of great differences in manner of living, the Trachoma I + II prevalence curves decrease in the same length of time with a parabolic curve (figs. 30 A and 31 A) indicates that factors which are inherent to the disease underlie the natural course of trachoma and that the course of trachoma at a later age may be modified by secondary factors. The curves show that several years must have elapsed after the initial infection before geographical differences in the trachoma curves become manifest.

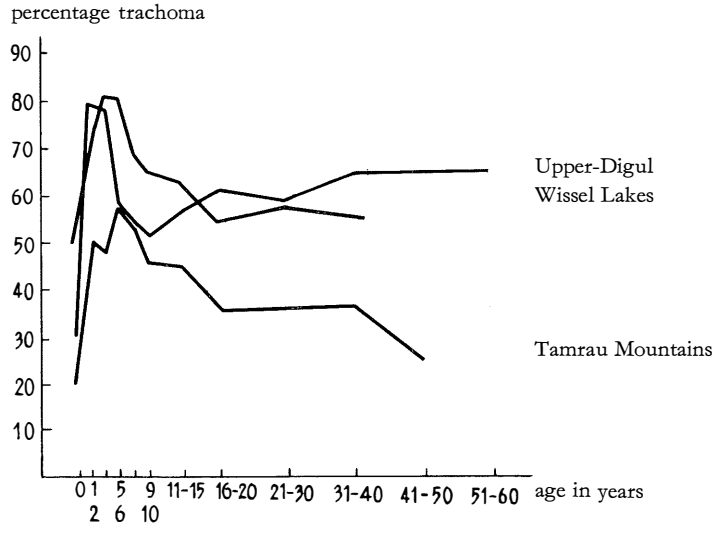


FIG. 31 - Superimposition of the trachoma prevalence curves of the regions Upper-Digul, Wissel Lake and Tamrau

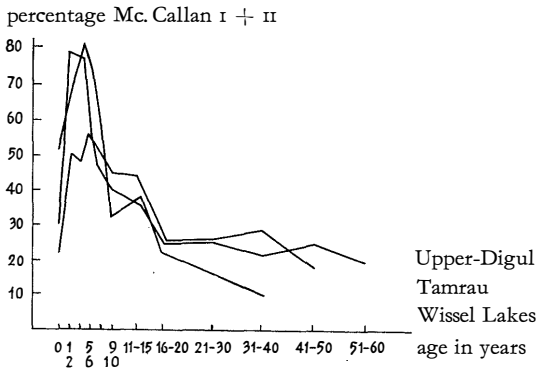


FIG. 31A - Superimposition of Trachoma I + II prevalences of the Upper-Digul, Tamrau and Wissel Lake regions previously represented in the figures 20B, 21B and 17B. The curves now are based on percentages of all individuals examined in the particular age groups

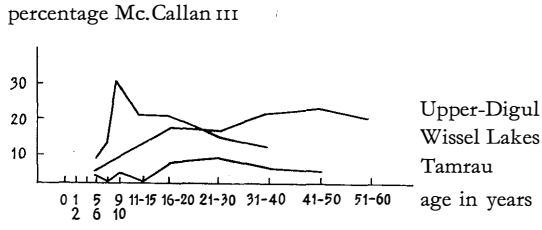


FIG. 31B - Superimposition of Trachoma III prevalences of the same three areas, also expressed in percentages of all individuals examined in the particular age groups.

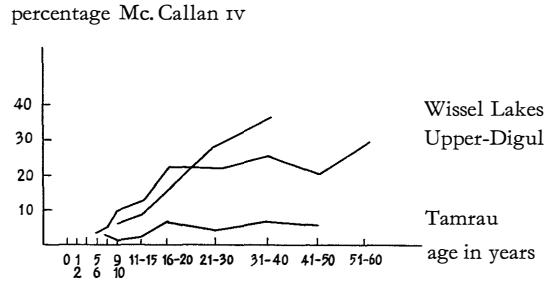


FIG. 31C - Superimposition of Trachoma IV prevalences of the same three areas, also expressed in percentages of all individuals examined in the particular age groups.

The Wissel Lake and Mimika areas are only 40 miles apart. Contacts between their tribes do exist. Yet, the trachoma prevalence rate curves of these two areas diverge widely (figs. 17A, B and 18A, B).

One can safely exclude the possibility of bacterial superinfections being the cause of these differences, since trachoma in both areas chiefly manifests itself as trachome pur.

The two areas differ markedly in climate (highlands at an altitude of 1700 metres versus tropical coastal climate) and in way of life (settled versus semi-nomadic existence). It is further unlikely that climatic conditions are responsible for these differences, for steeply rising Trachoma IV curves, as present in the Wissel Lake area, were also obtained in areas with a coastal climate (Sentani, Radja Ampat and Upper-Digul areas). This is in accordance with the generally accepted opinion that climate does not affect the course of the trachomatous process.[96]

The low percentage of scar formation in the Tamrau and Mimika regions, the population of which lead a nomadic or semi-nomadic life, is striking. The relative benignancy of trachoma in nomads is generally known, for that matter. In New Guinea a possible explanation for this may be that the nomads live under better hygienic conditions than the settled people do, as there is no domestic crowding. They do not suffer from 'nocturnal overpopulation,' in which the dark huts are crowded by a mass of humans, huddled together. The nomads live in primitive shelters which are often open to several sides so that light and fresh air may enter freely. (The trachoma virus is inactivated by drying.[36].) In the settlements the houses often lack window openings and several families may live together in one room.

Findings in New Guinea seem to indicate that the type of trachoma, prevailing in a certain region, will be determined at least partially by the frequency and intensity of viral reinfections.

The findings in the Upper-Digul region seem to be at variance with these findings. In spite of recent settlement there is already a rather high Trachoma IV prevalence in this region (fig. 31C). This might be due to secondary bacterial infections. Although this is a rather feeble

explanation, it is a well known fact that chronic bacterial superinfections may form a serious complication in trachoma.

This is shown by the serious types of trachoma prevailing in the Schouten Islands. Here, in one of the most densely populated regions of Western New Guinea, trachoma manifests itself mainly as trachome mixte.

The findings in the sparsely populated Wissel Lake region show that *bacterial superinfections* as such are not (always) sufficient to produce malignant types of trachoma.

We observed rather frequently in 'old' people of this region a chronic angular conjunctivitis of long standing (sometimes leading to severe ectropion) which in no way affected the malignancy of their co-existing trachoma.

Bacterial superinfections, however, noticeably affected the trachomatous process in more densely populated regions and in crowded settlements. As a result of increased secretion (lacrymation and pus formation) in secondary infected trachoma, the individual degree of infectivity is raised (Mitsui, 1955).

In densily populated areas and under poor hygienic conditions this will inevitably lead to *increased virus circulation* which may account for the development of malignant types of trachoma.

A striking illustration of the observation that population density affects the course of trachoma is the type of trachoma occurring in the villages of Fanfanlap and Lilintah. These two coastal settlements are extremely overcrowded and in this respect are a sharp contrast with the adjacent coastal villages which are more spaciously built and much less crowded. Trachoma runs a more severe course in the villages of Fanfanlap and Lilintah than in the adjacent settlements.

The influence of environmental conditions on the course of trachoma is a.o. mentioned by Fuchs[22], Vozza[6] and Nataf[59]. According to the W.H.O. Expert Committee on Trachoma[96] 'most observers consider that crowding is a factor contributing to the incidence and the severity of trachoma. Many nomadic peoples, although they may show a high incidence of the disease, often do not suffer much from disabling sequelae.'

Owing to the fact that the general disease pattern of trachoma is modified by environmental conditions, trachoma holds a unique position among infectious diseases as there is no analogue with other infectious diseases.

Laboratory research suggests the existence of *differences in antigenic properties* of the trachoma virus.[4, 80]

Factors, influencing the course of the disease are viral *infection*, *reinfection and superinfection*; the intensity of which is at least to some extent determined by the population density.

It is reasonable to suppose, however, that in addition to the factors mentioned there may be factors as yet unknown which participate in the determination of the course of trachoma.

One is inclined to attribute some influence to solar radiation. This factor however does not influence the development of malignant types of trachoma, since for instance in the Radja Ampat area, in which there was a marked difference in the development of the process, the factor sun light remains the same for all villages. Further, the people in the Central Highlands (altitude 1700 metres) which are exposed to more ultra violet radiation did not show malignant types of trachoma.

In Western New Guinea sand and dust have no influence on the development of malignant types of trachoma for reasons mentioned in the paragraph dealing with pterygium. Neither may any influence on the differences in the course of trachoma be attributed to flies as these are ubiquitous all-over in Western New Guinea.

Comparison of the various areas shows that the general state of nutrition of the population has no influence on the course and severity of trachoma.

SPONTANEOUS HEALING OF TRACHOMA IN WESTERN NEW GUINEA AND IN OTHER COUNTRIES (COMPARATIVE REMARKS)

The trachoma of Western New Guinea runs a subjectively symptom-free course in the large majority of cases and is often found as a chance observation during a routine examination. Subjective complaints are seldom heard, for even an extensive involvement of the eyelids and the presence of pannus does not cause much discomfort.
This relative absence of discomfort is one sign of the benignancy of trachoma in Western New Guinea. Other observations testifying to this are:

- Among 4237 cases of trachoma only 1 case of binocular blindness, 1 case of monocular blindness and 6 cases of monocular reduced visual acuity resulting from trachoma were found.
  These figures include the pilot study at Biak.

- The percentage of spontaneous cures without sequelae ranged from 25,9% to 68,2%.
- The total percentage of spontaneous cures ranged from 64,5% to 79%.

As has already been argued on page 74, these figures of spontaneous cures must be considered as *minimum* percentages.

These high percentages of spontaneous cures however are not just typical for trachoma in Western New Guinea. According to Mac Callan (1936) in a trachomatous country all children are infected within the first two years of life, among the mass of the population. By the evolution of the disease, many of these attain a natural cure.

The literature contains several reports in which either percentages of spontaneously healing trachoma or differences in prevalence between the young and more advanced age groups are mentioned.

Schimkin (1924) reported a trachoma percentage of 35% in school children and of 18 to 20% in adults in Palestine and Egypt.

Feigenbaum (1925) stated that more than 50% of trachoma disappeared without leaving any trace in the schoolchildren at Jerusalem.

Cange, Foley and Parrot (1935) reported from South-Oran (Algeria) in which country 10,6% of the trachoma cases showed either entropion or trichiasis, that 44,3% of all trachoma cases healed spontaneously, of which 32,1% with and 12,2% without scar formation. They presumed the real percentage of cures with restitutio ad integrum to be even higher and emphasized the natural healing tendency of trachoma.

Warouw (1935) in East Indonesia found that trachoma in over 50% of the cases has healed when the adult age is reached.

The ophthalmologists Thygeson and Forster (1939) examined all 630 inhabitants of two small Apache villages and found infection rates ranging from 12 to 34% for various age groups, children's rates being twice those of adults.

Recent literature contains reports of similar findings. For instance, Reinhards (1954) in Morocco found spontaneous healing in 26,5 to 60% of all trachoma cases. His study deals with cures which leave sequelae and shows that in Morocco cures with restitutio ad integrum are exceptional.

Guerra (1957) found that the percentage of trachoma cases in Ethiopia is highest among the age groups below 11 years and deduced from this that quite a number of cases healed spontaneously to a percentage approximating 45%. Though not explicitly mentioned he probably refers to the percentage of cures without sequelae.

Tailor et al. (1958), in a Punjab village in Pakistan found eye infections (the majority of which were trachoma) in 90% of all children and in 60 tot 70% of all adults.

Eiselen and Gear (1960) reported a maximum trachoma prevalence rate in South-West African infants up to two years of age of 73,33%; in adults of 15 to 60 years of age this figure was 53%.

Fuchs (1960) mentioned in the East African Kanuma's a trachoma percentage of 61% in children up to 11 years of age, decreasing to 35% after that age.

Previous reports are not unanimous, however, as regards the spontaneous decrease of trachoma prevalence with advancing age. For instance, Swanston (1953) reported that in the Fiji Islands trachoma prevalence increases after the age of 30 and Bietti (cited by Fuchs), who examined Arabian children, in some regions found spontaneous healing in 30% and in other regions with the same kind of population in 2% to 4%. However, the data of most authors can hardly be compared because of the disparity of the criteria used in the evaluation and the method of collecting the data. Many authors are convinced that trachoma may heal spontaneously; however, there is much difference in opinion as to the frequency of this phenomenon.

As will be dicussed more fully in the paragraph on epidemiological considerations, the course of the trachoma prevalence curve also depends on the stability of environmental and living conditions and on contingent treatment campaigns (e.g. as in the Fiji Islands). When mass treatment has been instituted, it is impossible to calculate the percentage of spontaneous cures.

This concise review of the relevant literature shows that the natural course of trachoma in Western New Guinea, where general therapeutic measures have never been undertaken, is not exceptional but more or less corresponds whith the healing tendency as observed in many other countries, such as Egypt, Palestine, East Indonesia, North America, Pakistan and several parts of Africa.

Though the absolute figures may differ, the over-all trend is similar.

Conclusions

Mass screening of a representative sample of the Western New Guinea population shows that trachoma is a condition with a high infectivity and a low virulence, developing into malignant types only when favoured by poor hygienic conditions, often in association with other factors such as bacterial superinfections.

The investigation as reported here and the comparison of trachoma prevalence rates for several age groups in different countries strongly suggest that statements on the malignancy of trachoma based on data obtained from eye departments tend to be deceptive, since the symptom- and complaint-free cases which in several countries constitute the large majority, will not be seen by the clinician.

Study of endemic trachoma forces one to the conclusion that the clinical concept of trachoma, emphasizing the malignancy of the disease, is incorrect.

EPIDEMIOLOGICAL CONSIDERATIONS

As shown in the figures 16A-21A and figure 22 the trachoma prevalence increases sharply in the first year of life, and continues to rise in the following year. At the age of two, on the average, the maximal trachoma prevalence has been reached. These observations signify two things: the chances of infection are very high and infection is acquired at home. In view of the extremely close contact between mother and baby (see page 12), it is only reasonable to suppose that the infection is transmitted from the mother (or parents) to the baby.

In the adult age group a relatively large percentage of trachoma cases has healed with or without leaving sequelae (figures 16-21A and B), but a fair amount of infectious cases remain. Furthermore it is generally known that it is difficult to determine exactly the time of healing of a disease such as trachoma, which sometimes may show only slight symptoms or remain inactive for prolonged periods.

Taking into account the high percentage of smears positive for inclusion bodies found with simple equipment, form conjunctivae which only showed papillary hypertrophy and even from apparently normal eyes, it will be evident that the virus prevalence rate must be considerably higher than one is inclined to deduce from the trachoma prevalence rate.

This conclusion is also valid for areas with a lower trachoma prevalence, for instance the Mimika region (average percentage 38%). Here, in the age group 1-2 years a peak prevalence of 63% is reached.

The presence of a large horizontal spread of the infection in this district (in spite of the low average trachoma prevalence) is shown by the distribution of the trachoma cases over the various houses, c.q. family-units: in 85% of these one or more individuals were found with trachoma. It stands to reason that the subclinical stages of trachoma have not been included in these figures. In the Upper-Digul region, where the average trachoma prevalence amounts to 61%, all houses without exception proved to be infected with trachoma.

The trachoma prevalence curves of the various regions therefore do not reflect the exact figure of infected individuals, but represent a state of equilibrium between cases with clinically manifest trachoma on the one hand and subclinically infected and normal individuals on the other. This state of equilibrium between host and virus is determined by a complex of factors such as chances of infection, re-(super-) infection, immunity, environmental conditions and possibly differences between virus strains. As in most areas of Western New Guinea environmental conditions have remained unchanged for long periods of time this equilibrium is a stable one; the trachoma prevalence curves representing an endemic prevalence.

Depending on the living conditions and the density of the population in a given area this equilibrium between host and virus is adjusted to a certain level. This level determines the clinical character of trachoma, in particular of scar formation. It has been found that scar formation is more frequent and pronounced in densely than in sparsely populated areas.

In figs. 30A and 31A it is shown that the drop in the Trachoma I + II prevalence curves is practically identical in regions which are quite different from an epidemiological point of view. The tendency to spontaneous cure is apparently independent of the level at which equilibrium is established.

It is the current opinion that trachoma leaves only a relative and short-lasting immunity. This has been confirmed by Tsutsui's reinfection experiments with volunteers.[90] In an area in which trachoma is ende-

mic, immunity may be maintained however, by repeated reinfections, thus forming a factor in maintaining the state of equilibrium mentioned above.

The extent to which environmental and living conditions may disturb the extant equilibrium is beautifully shown by the trachoma prevalence curve of the Upper-Digul area (figures 20A and B). The curve in fig. 20A shows an initial steep increase, followed by a marked decrease of trachoma prevalence after the age of 3 to 4 years; this decrease continues up to the ages 9 to 10, after which the curve gradually rises again, in distinction to the curves of all other areas screened.

That this is due to new infections, is proved by the higher Trachoma I + II and Trachoma III prevalences which in the age groups 31-50 years amount to 21,5% and 21% resp. Together with the percentage Trachoma I + II of the Tamrau Mountain Range, this Trachoma I + II percentage is among the highest of all areas screened, while the Trachoma III prevalence of the Upper-Digul region in the age group 31-50 years is the highest of all areas. This is most likely due to clinically manifest reinfections of Trachoma IV cases.

The changes in living conditions of these people provide a likely explanation of this marked disparity. These people have changed from a purely nomadic to a settled way of life only in very recent times (see page 17). As has already been discussed on page 80, such a change entails an unfavourable turn in hygienic conditions in the sense that the increased contact rate, i.e. increased rapidity of virus passage, results in quantitative changes in the interrelationship between host and virus.

The equilibrium is disturbed in favour of the virus, tending to an increase in prevalence. This process continues until a new equilibrium is reached at a different level. Therefore the curves shown in figures 20A and 20B are unstable curves from which the percentage of spontaneous cures cannot be calculated at this moment.

In the Tamrau Mountain Range, in which the more advanced age groups also show a high Trachoma I + II prevalence (25% in the age group of 31 years and over) the prevalence curve also shows a drop after the maximal prevalence. This, however, does by no means exclude reinfections. As has been described on page 20, the population of this area, in spite of a tendency to settle, still maintains a more or

less nomadic way of life, so that proper assessment of each of the factors enumerated before, is hardly possible. The relative high prevalence of active trachoma stages in the more advanced age groups (fig. 21 B) and the horizontal level of the trachoma prevalence curve in these age groups (fig. 21 A) might suggest a rather recent introduction of trachoma in this area.

However, as early as 1877 intensive contacts of this population with the coast have been reported (page 20). There they had contacts a.o. with people coming from the Schouten Islands, where a malignant type of trachoma occurs frequently.

Moreover, only relatively few individuals, in particular those of the younger age groups, could be examined. The Tamrau Mountain families are small due to an extremely high perinatal- and infant mortality rate.* Because of these factors I cannot satisfactorily interpret the trachoma curves for the Tamrau Mountains.

Especially in the Tamrau Range, in which an extremely benign type of trachoma prevails, the findings of a virus sample survey would be very interesting. It would open up ways to decide whether trachoma here is moderately endemic or highly endemic but so benign that many infections remain subclinical throughout.

TRACHOMA AND MASS TREATMENT POLICY

The findings in the Upper-Digul area indicate that an average trachoma prevalence of 61% means that the population is almost completely infected. An average trachoma prevalence of 38%, such as has been established for the Mimika area, indicates that the area is to be considered as highly endemic. Treatment campaigns in such highly endemic areas therefore are likely to succeed only if they are not limited to a selected group of individuals, but cover the whole

* Official reports about the perinatal – and infant mortality rate in the Tamrau Mountain Range are still lacking. Questioning of the mothers of the villages Sedjak, Bamfot and Bama by the District Medical Officer J. W. van der Kouwe revealed the following figures: The present generation of mothers has produced 301 children. Of these 88 died during infancy (mostly immediately after birth). 31 died in the toddler age. 11 died at a later age.

population. Otherwise, the large virus reservoir as constituted by healthy carriers and clinically healed cases, will remain intact. Most treatment campaigns, which in order to remain feasible are of necessity carried out only for a limited period of time, are utterly inadequate to interrupt the existing infectious circle and achieve a permanent control of the disease. Specifically in those areas with poor hygienic and living conditions, reinfection of treated (and cured) individuals will occur. Moreover, since trachoma is accompanied by only a temporary, relative immunity, the incidence* after treatment will increase.

The following observations may be helpful in the planning of mass treatment campaigns:

1. In order to determine which categories of the population should be treated, a virus sample survey of a representative sample of the population, including healthy people, should precede any campaign. Only a virus sample survey will provide a well-founded insight into the dissemination of the trachoma virus. In the virus sample survey the culture-method is to be preferred.
2. Should such an investigation show that a large number of subclinical cases is present, any method of case-finding and case-treatment will necessarily be ineffective. Likewise, treatment of certain selected groups of the population, such as schoolchildren, will result in only partial and temporary success.
3. Control and final eradication of trachoma by mass treatment campaigns in this case can be obtained only through treatment of the whole population.
4. Results of trachoma control measures will also depend on the extent to which health education and improvement of hygienic and living conditions will aid in preventing further transmission of the disease.

* The term 'incidence' is used as recommended by the W.H.O. Expert Committee on Health Statistics, Sixth Report, Technical Report Series no. 164, Geneva 1959, for use to describe the measurement of frequency of illnesses commencing during a defined period of time.

THE DESIRABILITY OF ANTI-TRACHOMA MEASURES IN WESTERN NEW GUINEA

The decision whether or not such expensive and time and energy consuming mass treatment campaigns should be realized depends on the nature of the disease. Disease and treatment, ends and means are always related, or should be so, in a proportionate way. Since the study of trachoma in Western New Guinea did show that it is a benign and largely asymptomatic condition with a marked tendency to spontaneous healing and only exceptionally leading to invalidation, general therapeutic measures in most areas seem unnecessary.

A possible exception should be made for the Schouten Islands. No complete coverage could be made there, but the preliminary impressions were that malignant types of trachoma occur frequently. A more detailed study of the situation in this area is certainly desirable.

Part 2 - Blindness in Western New Guinea

DEFINITION OF BLINDNESS

Individuals were regarded as blind when the visual impairment prevented their participation in common daily life. Such economical blindness was considered to be present when the visual acuity was less than 2/60 (inability to count fingers at a distance of 2 metres).

PREVALENCE OF BLINDNESS

Excluding the pilot study at Biak, only 15 blind people were seen among a total of 7808 individuals during the entire survey. From these figures one might draw the conclusion that the percentage of blindness is 0.19%.

In order to arrive at a correct evaluation of this figure, it should be borne in mind that the aborigines in many places live under utterly primitive conditions and among extreme hardships, in a continuous struggle for life. The life-expectancy of blind young children under such conditions is exceedingly low, and also the life-expectancy of blind adults is much lower than that of normal individuals.

Furthermore, blind people were sometimes only presented after we had explicitly asked for them; therefore it is quite possible that too few cases of blindness have been included in the survey. The figure of 0.19% therefore certainly does not reflect the seriousness of the problem.

CAUSES OF BLINDNESS

In addition to the 15 cases of blindness seen during the survey, I have registered all the binocular blind Papuans who consulted me at the Central Hospital at Hollandia and at the peripheral hospitals which I regularly visited as Consulting Ophthalmologist. The cases of bino-

cular blindness examined, totalled 85. Table 3 shows the causes of blindness in order of frequency.

TABLE 3 - Causes of binocular blindness

	number of blind
cataract	44
maculae corneae (comprises both perforating and non-perforating injuries, inflammations, keratomalacia, staphylomata etc.)	17
maculae corneae + cataract	1
atrophia bulbi	6
atrophia bulbi + cataract	1
trachoma	4
atrophia nervi optici	3
retinitis proliferans (either non-diabetic or following uveitis)	2
sympathetic ophthalmia (not verified histologically)	2
glaucoma simplex	2
uveitis	1
uveitis + cataract	1
hydrophthalmia	1
Total	85

This table shows the most important cause of blindness in West New Guinea to be cataract followed by corneal disorders. Trachoma plays only a very minor role among the list of causes. It should be pointed out that the conditions causing blindness in children (vitamin A deficiency!) largely belong to the group of corneal maculae. Therefore this group is in reality larger than the table would lead one to believe, for the same reason as given before (the high mortality rate of blind chlidren).

PREVALENCE OF MONOCULAR BLINDNESS

The number of cases of monocular blindness encountered during the survey totalled 131 (i.e. 1.67%).

CAUSES OF MONOCULAR BLINDNESS

The causes of monocular blindness have been listed in order of frequency in table 4.

TABLE 4 - Causes of monocular blindness

	number of monocular blind
maculae corneae (tramatic or non-traumatic, with or without secondary glaucoma, keratomalacia, staphylomata etc.)	49
maculae corneae + cataract	3
maculae corneae + luxatio lentis	2
atrophia bulbi	34
perforatio bulbi	9
cataracta traumatica	10
cataracta (prae) senilis	10
cataracta congenita	2
pterygium	8
trachoma	1
uveitis + cataract	1
strabismus convergens gravis	1
hydrophthalmia	1

In monocular blindness injuries form the principal cause, followed by inflammations. This is correlated with the ways and means of living of the population, for instance their methods of hunting. Arrow injuries constituted a most important category, just as did injuries caused by boughs or high grass, acquired while running through the bush.

In the category of monocular blindness as well, trachoma occupies a place of minor importance.

Although cataract constitutes the most important cause of blindness, I was struck by the very limited number of cases of mature cataract observed during my years in Western New Guinea. Also in the Territories of Papua and New Guinea, Man and Löschdorfer noticed the relative rarity of cataract as compared with India and Ceylon. Unfortunately, these authors do not mention any figure concerning the average life-expectancy in these countries.

To what extent this low frequency is determined by race and climate cannot be determined with any certainty. We know, however, that the average life expectancy in Western New Guinea is low so that the aborigines do not often reach an age at which cataract begins to develop. For instance, in the Central Mountain Range, it is exceptional to find a person of 40 years or over.

In the future, in view of the increasing economic development and

general medical care, cataract may be expected to occur more frequently.

A great part of the listed causes of blindness is constituted by the so-called 'preventable diseases', such as inflammations and injuries. Health education which stresses the necessity of immediate treatment of eye infections might prevent a large number of cases of blindness.

Concerning monocular blindness resulting from pterygium, it should be pointed out that 6 of the 8 cases observed were found among the Radja Ampat Archipelago population. In all of these cases, pterygium was present also on the other (non blinded) eye. In the Radja Ampat Archipelago, among 808 people over the age of 20, there were 112 cases with pterygium! This figure clearly shows the importance of this condition.

Preventive measures, such as sun glasses are of course impracticable for this sea-faring people.

The only solution is to be found in great alertness of the local medical authorities who should devote special attention to the detection and treatment of individual cases.

Part 3 - Other Eye Diseases

EYE DISEASES DUE TO MALNUTRITION

Of all ophthalmological disorders caused by malnutrition those caused by deficiency of Vitamin A are readily recognized under field conditions. This is in marked contrast to the disorders resulting from deficiency of any member of the Vitamin B complex, specifically riboflavin deficiency, of which the diagnosis can hardly be made without an additional general physical examination. For the diagnosis of minor symptoms of Vitamin B deficiency an advanced knowledge of pediatrics is indispensable. I have not carried out a general physical examination of any idividual. Therefore the discussion will be limited to Vitamin A deficiency.

According to Duke-Elder the following *conjunctival* changes are early symptoms of Vitamin A deficiency:

1. A lack of lustre, intensified by keeping the lids open for ten seconds.
2. Wrinkling of the conjunctiva, first evident in the palpebral region, running concentric with the limbus. This is particularly well visible when the patient looks sideways.
3. Bitôt's spots-small, white, sharply-outlined patches covered with material resembling dried foam which are not wetted by tears.

The development of *corneal* xerosis is preceded by pre-xerosis corneae (dryness of the cornea when exposed to air).

The diagnosis of conjunctival pre-xerosis is attended with difficulty during field work and particularly during this survey, since in many children and adults in Western New Guinea a thickening of the bulbar conjunctiva is present. When the patient looks sideways this thickened conjunctiva may show concentric wrinkles and occasionally gives the impression of a conjunctival lack of lustre.

As in other negroid races, marked pigmentation of the corneal

limbus and bulbar conjunctiva is found in the Papuans. The latter one is localized in the palpebral region. This in distinction to the pigmentation of Vitamin A deficiency, which is often localized in the lower part of the bulbar conjunctiva, the semilunar fold and the lower fornix.

I have been in a position to try out the effect of high doses of Vitamin A (100.000.U daily for several weeks) on these cases and have carried out a follow-up of several months. This treatment had not the slightest influence on this condition. Ex iuvantibus, I inferred that this pre-xerosis-resembling disorder was not caused by Vitamin A deficiency.

Therefore, in fieldwork a reliable diagnosis of pre-xerosis can not be made, unless a history of night-blindness is elicited.

In the SCHOUTEN ISLANDS ocular diseases due to Vitamin A deficiency have a certain importance. Practically during any of my regular visits to the Hospital at Biak, of which I was Consulting Ophthalmologist, I found cases of active keratomalacia. In a discussion with the District Medical Officer, he informed me that night-blindness was a regular complaint of his out-patient clients.

The regional diet varies with the localization of the villages (van der Hoeven). When a village has no gardens and consequently no own staple food, the situation is always critical. A very unfavourable situation for instance, is present in the village of Sowek (Island of Supiori). Here the staple food is the germinating mangrove fruit (Breguiera Eriopetaria), the nutrient of which is starch only. Sea weed, which is found in large quantities on the reefs, is a customary type of grocery. The state of nutrition is very poor in this village. Symptoms of malnutrition were observed in 17% of the toddlers. In addition, great importance is to be attached to the food taboos which are nearly always protein taboos. The taboos forbid the eating of fish before the end of the first and the consumption of meat before the end of the second year of life. The effect of this is always highly noxious to pregnant women, lactant mothers and infants (van der Hoeven).

During the survey of the SENTANI LAKE population no cases of Vitamin A deficiency were observed; however, the large number of individuals with corneal maculae, especially present in the age groups of 10 years and over, was marked. Many cases of corneal maculae were similar. They were usually located in the lower half of the cornea at some distance of the limbus, nearly always crescent-shaped and occasionally associated with a staphyloma of the other eye. The paramarginal localization in these cases was somewhat more central

than in marginal corneal ulcer. The total number of cases with corneal maculae amounted to 5.1% of the total population; in the age group 0-10 years this figure totalled 1.1%. Although these cases in retrospect can hardly be diagnosed with any certainty, I strongly suspect that Vitamin A deficiency played a role in their pathogenesis.

In 1955, the Division of Maternal and Child Health started its activities in this area. The near-by capital Hollandia also influenced the economical situation. These two factors explain the marked decrease in the frequency of maculae corneae in the youngest age groups.

At the out-patient department of the Eye Clinic of the Central Hospital of Hollandia, I observed only rare cases of xerosis and keratomalacia.

In the UPPER-DIGUL region I found 2 cases of active keratomalacia. Other symptoms, such as xerosis or Bitôt's spots, were not observed. Cases of macula corneae in this region averaged 6%. In this disorder no definite relation with Vitamin A deficiency could be established. The most important source of food here is sago (Metroxylon rumphii), the nutrient of which is starch only. A potential source of Vitamin A are the vegetables collected in the bush. It is unknown, however, whether a sufficient quantity of these vegetables is consumed. Bananas which contain carotene (source of Vitamin A) when ripe, are abundant. The usual technic of preparing these, however, is to roast the unripe bananas in the fire.[7]

The RADJA AMPAT archipelago and the TAMRAU MOUNTAIN RANGE have the lowest percentages of maculae corneae (1.7% and 3.6% resp.). No symptoms of Vitamin A deficiency were found. In both regions sources of Vitamin A are abundant. In the Radja Ampat archipelago fish is the daily food, whereas the Tamrau population consume a liberal quantity of natural green vegetables in which this region abounds.

Among the WISSEL LAKE population no cases of Vitamin A deficiency were met with. The percentage of cases with maculae corneae averaged 4.2%, a part of which was caused by epidemic keratoconjunctivitis. The diet, consisting chiefly of sweet potatoes, is poor in calories and proteins.[29] The carotene-rich leaves of the sweet potato are eaten as vegetables. An adequate supply of Vitamin A is

derived from these vegetables which are given as additional food to the babies. The mother minces the leaves by chewing them.

No cases of Vitamin A deficiency were seen in the MIMIKA AREA. The percentage of cases with maculae corneae averaged 4.2%. The role of Vitamin A deficiency in this disorder here is not clear. The state of nutrition in the different parts of this area varies considerably. Particularly in the eastern part, where the gardens are situated much further inland and the people live less frequently near the coast where fish abounds, the state of nutrition is worse than in the western part of this area.

Summary and conclusions

Eye disorders due to Vitamin A deficiency are of importance on the Schouten Islands and have probably been so in the past in the Sentani Lake area.

The type of screening program, in which a representative sample of the population was examined was less suitable for obtaining definite knowledge of the importance of these disorders, as a sure diagnosis of them can only be made in toddlers, the groups of which were not numerous enough for this purpose.

PTERYGIUM

It is commonly accepted that climatological conditions play a predominant role in the appearance of pterygium. Mulock Houwer, Izac, Kerkenezov, Hilgers and Forsius and Erikson showed that pterygium occurs much more frequently in people leading an out-of-door life than in those who do not. Duke-Elder and Meigot de Treigny regard dust and wind, Ringland Anderson regards desiccation as aetiological factors. Hilgers, however, in his thesis 'Pterygium on the island of Aruba' pointed out that there is no evidence to prove the aetiologic effect of dust, wind, heat or desiccation, because a high incidence of pterygium has been observed both in countries where wind and dust are usually absent, such as West Java, and in regions where humidity is relatively high, such as Aruba. Hilgers draws the conclusion that solar radiation seems to be the harmful open-air influence responsible for the formation of pterygium.

In Western New Guinea the prevalence of pterygium showed appreciable regional differences. This is shown in table 5.

TABLE 5 - Prevalence of pterygium in six New Guinea regions

Region visited	Number of people examined, aged 20 years and over	Number of cases with pterygium aged 20 years and over	Percentage with pterygium	Number of cases with (monocular) blindness due to pterygium
Radja Ampat	808	112	13.8	6
Sentani Lake	464	35	7.5	2
Wissel Lakes	484	26	5.3	0
Mimika region	855	21	2.4	0
Upper-Digul	655	1	0.1	0
Tamrau Mts.	499	1	0.2	0

The prevalence of pterygium in several regions according to age groups has been represented in fig. 32. As the number of cases in the age group of 61 years and over from the Sentani Lake region is too small, it has been excluded.

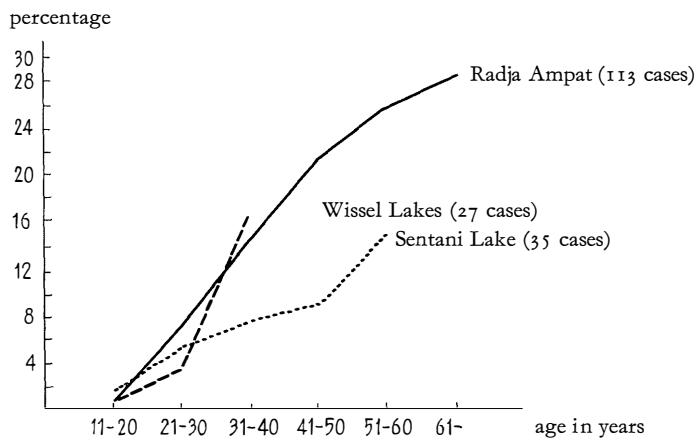


FIG. 32 - Prevalence rates of pterygium according to age groups in different areas of Western New Guinea
Rates of Mimika, Upper-Digul and Tamrau areas are too low to be represented in the diagram

Table 5 and fig. 32 clearly show that the prevalence of pterygium reaches the highest values in the Radja Ampat, Wissel Lake and Sentani-Lake regions. Of these three, the Radja Ampat archipelago has by far the highest number of blind.

Also the curve of the Wissel Lake area is steep. No individuals with blindness caused by pterygium were noticed there. The short life-expectancy is the probable cause of this phenomenon.

High percentages of pterygium occur only in regions in which the inhabitants are continuously exposed to intensive light: the Radja Ampat archipelago, the Wissel Lake and Sentani Lake regions lie near large lakes or the sea. In the river-districts Mimika and Upper-Digul, the population also lives near water and in the Mimika area it temporarily lives on the coast, but in these regions the day-light in many places is subdued by the high tropical rain-forests extending to the river banks. In the heavily forest-clad Tamrau Mountains the population mainly lives in strongly subdued day-light. Pterygium is practically non-existent here.

Sand cannot be a causative agent in Western New Guinea, as, with the exception of some very narrow beaches, no sand-surfaces are present in the humid, entirely bush-covered Western New Guinea.

I feel that these observations support the view that prolonged, intensive solar radiation constitutes an important factor in the development of pterygium.

ARCUS SENILIS

According to Duke-Elder, arcus senilis is a peripheral annular lipoid infiltration of the corneal stroma which is of constant occurrence in later life. It is essentially a simple senile degeneration, falling into the same category as atherosclerosis.

The frequencies of arcus senilis as reported by various workers (Hinnen, Toulant, Rohrschneider, Strömgren, White, Forsius and Fischer) are not comparable, since they are the results of widely divergent methods of investigation. For instance, the findings of Rohrschneider were obtained by microscopical examination of corneal

sections, stained with Sudan III, whereas Forsius, Hinnen and Fischer carried out their investigation with the slit-lamp microscope. Because of this, the frequency of arcus senilis as reported by the latter authors is considerably higher than that found by workers who did not use the slit-lamp microscope (Toulant, Strömgren, White).

Based on an investigation of 4400 eyes and an analysis of the data of Rohrschneider (200 eyes) and Gjessing (4768 eyes), Fischer pointed out that the frequency curves of senile changes of the eye, like arcus senilis, depigmentation of the irisstroma and also of the lens opacities, increase with age in a regular S-shaped curve, which has all the characteristics of a saturation curve. This is shown in fig. 33.

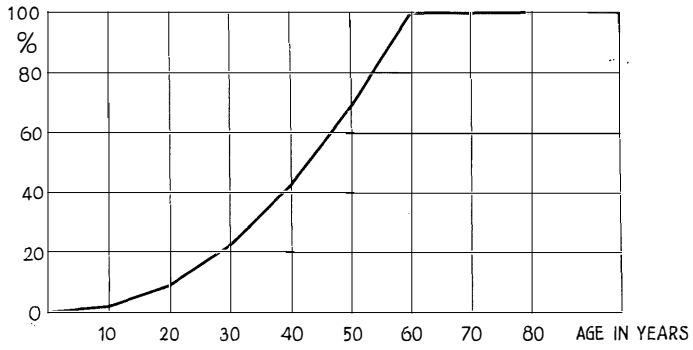


FIG. 33 - Frequency curve of arcus senilis after Fischer. The saturation is reached at a frequency of 100 percent

In the six New Guinea regions both incipient and fully developed stages of arcus senilis were registered. The frequency of arcus senilis in the various age groups is listed in table 25 (Addendum) and represented graphically in fig. 34.

As can be seen in fig. 34 the frequencies in the various age groups as recorded in the Sentani, Upper-Digul, Radja Ampat and Mimika regions are very similar to each other. In distinction to this, those noted for the Tamrau Mountain and Wissel Lake regions (both mountainous areas), are appreciably higher.

All the percentages of arcus senilis of the Tamrau and Wissel Lake regions marked with an asterisk in table 25 (see Addendum), show a statistically significant difference from the overall percentages of the corresponding age groups of the other 4 areas combined.

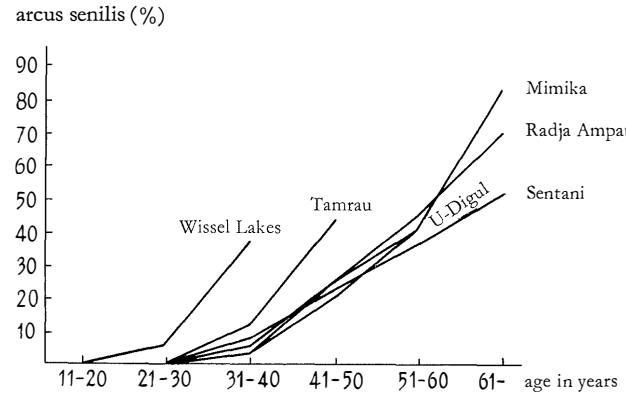


FIG. 34 - Prevalence rates of arcus senilis according to age groups in six New Guinea areas

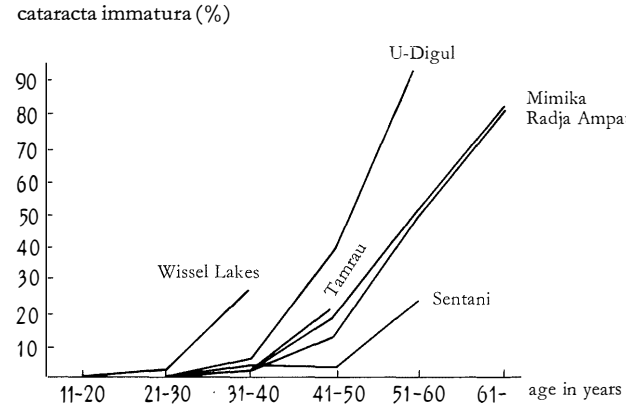


FIG. 35 - Prevalence rates of cataracta immatura according to age groups in six New Guinea areas

Comparison of fig. 34 with the S-shaped saturation curve as found by Fischer (fig. 33) shows that the initial part of a saturation curve is also present in the six areas screened. In New Guinea saturation is not reached, however. This is easily explained by the fact that the corresponding older age groups do not exist, owing to the low life-expectancy of the population of Western New Guinea.

Conclusion

In the Tamrau Mountains and the Central Highlands the population is still living under extremely primitive and harsh conditions, without adequate nutrition and virtually without clothes. The climate has lost its tropical characteristics at this altitude. Under these conditions the ageing-process starts considerably earlier and life-expectancy is much shorter than that of the inhabitants of Western New Guinea who are living under more favourable conditions, such as for instance those of the coastal population.

It is unlikely that the difference in prevalence of arcus senilis between the various areas is caused by differences in the state of nutrition. A lower prevalence of arcus senilis is met with both in an area in which the general food position may be called rather satisfactory (Radja Ampat archipelago) as well as in an area in which the food position is much less favourable (Upper Digul region). Also in the literature arcus senilis is not known at the present time to have any nutritional significance (Mac Laren)*.

The higher prevalence of arcus senilis in similar age groups in these two areas, as compared with the other four areas screened, indicates that the prevalence of arcus senilis, present in a certain age group, may serve as an objective standard for establishing the presence of an early ageing-process in a population.

CATARACTA IMMATURA

Immature cataract has also been recorded during the survey. The majority showed the nuclear type of cataract.

The prevalence of immature cataract in the six regions as distributed over the various age groups is represented graphically in fig. 35 and is listed in table 26 (Addendum).

Also in fig. 35 the initial stage of an S-shaped curve is conspicious. 'Saturation' is absent for reasons already indicated in the subject dealing with arcus senilis. The Wissel Lakes show the highest percentage of immature cataract in the corresponding age groups just as is the case with arcus senilis.

* Mac Laren, D. St. (1963). Malnutrition and the eye. Academic Press. New York and London.

The percentages marked with an asterisk in table 26 (Addendum) show a statistically significant difference with the overall percentage for the corresponding age groups in the other 4 areas combined. Because of the great variations in frequency between the various areas, no conclusion can be drawn.

GLAUCOMA

Glaucoma simplex

Any investigation as to the occurrence of glaucoma simplex is only valid if routine tonometry has been carried out; the examination should preferably include tonography and provocationtests, because subjective complaints and changes in the ocular fundi only develop in a more advanced stage of the disease. It is unlikely that such cases will be found in a population with a low life-expectancy.

Such a full examination has not been feasible within the frame of the mass screening survey as I carried out in Western New Guinea.

Glaucoma simplex however does occur among the native population. This is illustrated by the case of a 50-year-old blind Papuan, whom I examined at Hollandia's Central Hospital. Examination revealed the presence of a typical end-stage of bilateral glaucoma simplex with a markedly raised intraocular tension and glaucomatous excavation of the optic discs. Gonioscopy revealed an open angle.

During the survey in the Upper-Digul area a blind woman of 51 years of age was diagnosed as having glaucoma simplex. Unfortunately, the primitive field conditions did not permit a more detailed examination in this case.

Primary acute glaucoma

I have not observed a single case of primary acute glaucoma among the natives.

Secondary glaucoma

This condition has been observed several times during the survey. In most of these cases, glaucoma developed as a complication of anterior segment disorders.

ARTEFACTS AROUND THE EYE

The artefacts observed around the eye can be divided into three groups:

1. paintings
2. tattooings
3. scarifications.

1. The materials used for paint which are applied around the eyes, but also on other parts of the body, consist of red clay, white ashes, lime, soot and mud.
   In some areas they are applied for the celebration of ceremonial feasts. They will not be discussed here.

2. Tattooings are used by both sexes for cosmetic reasons. Many parts of the body may be tattooed in a large variety of patterns (fig. 36, page 108).
   Fig. 37 shows a woman from the Tamrau Mountains with a tattooing around the right eye.
   Tattoo marks are especially encountered in Northern New Guinea. As stains either charcoal or soot are used.
   In the Schouten Islands the pigment of the squid is used as well. The pigment is deposited under the skin by means of a thorn of the sago-palm tree.

3. Scarifications are applied on many parts of the body in many variations in both sexes.
   Only those around the eye will be discussed here.
   In the areas visited in South Western New Guinea I often observed dozens of fine, parallel, intracutaneous scratches on the forehead, about 1 centimetre long.
   They are applied by means of a bamboo knife.
   Their function is to cure headache and fever.

In the Tamrau Mountains deep vertical scarifications in the superciliary region were frequently observed (fig. 38). They give the impression of having been applied for cosmetic reasons, which, however, is not the case. According to local information these scarifications are the result of a therapeutic ritual against headache.

A third type of scarification, observed in 22 instances in the Mimika and Upper-Digul districts consists of a lesion running over almost the full width of the upper eyelid, parallel to the lidmargin. Secondary healing produces an irregular scar (fig. 39). It has been observed in young infants and adults of both sexes alike. Again, this type of scarification is intended to cure headache. As malaria is notorious for producing severe headaches, the frequently observed scarifications of the types mentioned, may be related to the presence of this highly endemic prevailing disease.

Therapeutic scarifications have been reported in the Ajamaroe region (South Vogelkop) by van der Hoeven. This concerns abdominal scarifications, indicating the course of splenomegaly. According to van der Hoeven the aborigines believe that these scarifications counteract the influence of evil spirits.

As early as 1858, van der Goes reported tattooings and scarifications in the Humbolt-bay Papuans. These are extensively discussed in Galis' thesis (1955). Several tattoo marks in the face and around the eyes are described and illustrated. The scarifications are applied with a bamboo knife. Galis contended that these scarifications have a mixed aesthetic-religious significance.

The application of artefacts for cosmetic reasons nowadays is a rapidly disappearing habit.

Besides the diseases discussed in the previous pages, other eye diseases have been registered as well. These have been listed in table 6 on page 107.

TABLE 6 - Miscellaneous eye diseases

	Wissel Lakes	Tamrau Mts.	Radja Ampat	Mimika	Sentani Lake	Upper-Digul	Total
Albinism				3			3
anterior synechia				7	3	10	20
calcareous deposits (limbal)						6	6
congenital cataract	3	1		1	1		6
chalazion		3	3	2		2	10
congenital glaucoma					1		1
corneal foreign body		1		2			3
convergent strabismus		1	3	1	1	1	7
corneal infiltration	1	1		2			4
dermoid cyst						1	1
divergent strabismus			1	2	1	4	8
ectopia pupillae	1						1
ectropion	4		2	1		2	9
flocculi	2	2	8	18		9	39
furunculosis of eyebrow (infected scarifications)		2					2
hemangioma of conjunctiva	1	1				2	4
heterochromia iridum				1			1
hordeolum	1					2	3
iridodialysis	1						1
iris atrophy	2	1	8	12	4	3	30
iris coloboma	2			1			3
iritis (acute)						1	1
lagophthalmos						1	1
lepromatous infiltration of eyelid		1					1
lid traumatism (including scarifications)	2	2	2	18	1	14	39
luxation of lens	1		1			2	4
molluscum contagiosum of eyelid			4	1			5
nevus of lid margin	3	5	6	5	1	3	23
nystagmus		1		2		2	5
peripunctal nevus	1	1	3			1	6
posterior synechia			2	9	1	10	22
pupillary membrane remnants		1		1		1	3
senile entropion	1			1		1	3
swelling of lacrimal gland	1			1		1	3
tumor of eyelid (benign)	4		2	4	1	2	13
uveal ectropion			2	2		1	5
xantelasma			1				1

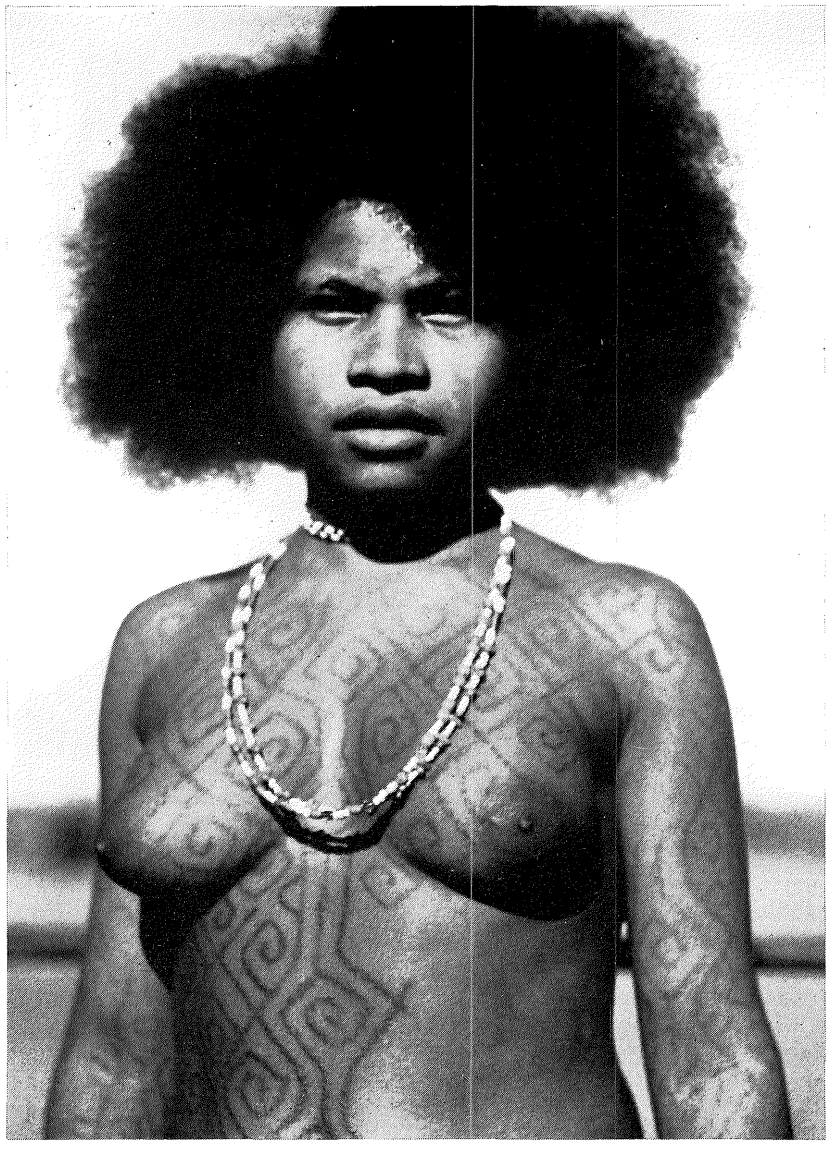


FIG. 36 - Female of New Guinea's north coast showing tattoo marks

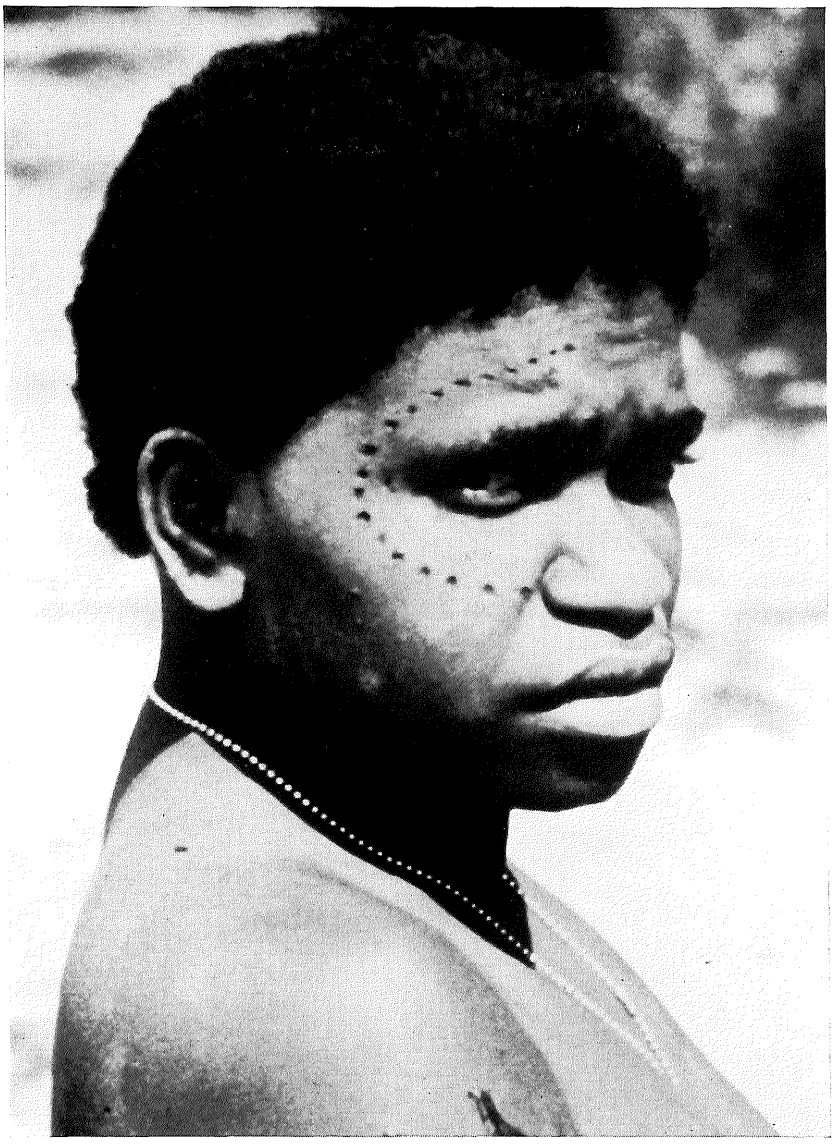


FIG. 37 - Female from Tamrau Mountains with periocular tattoo marks

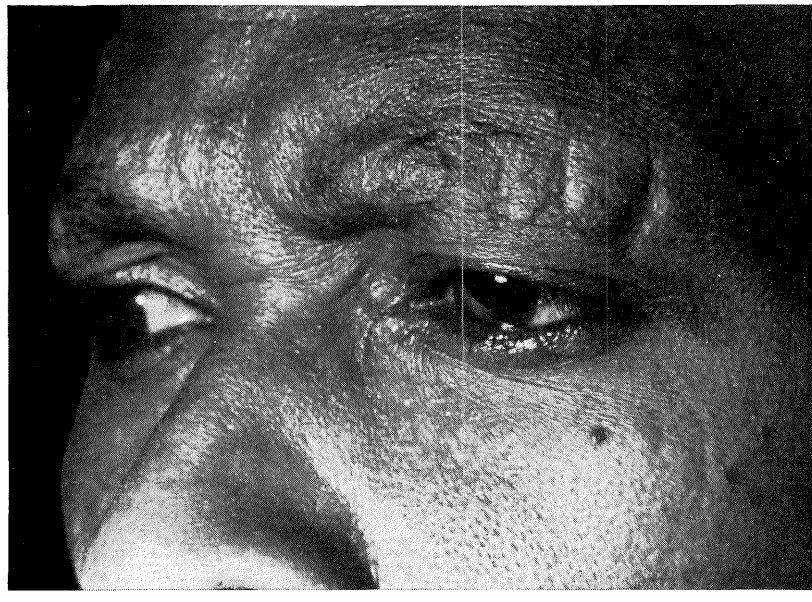
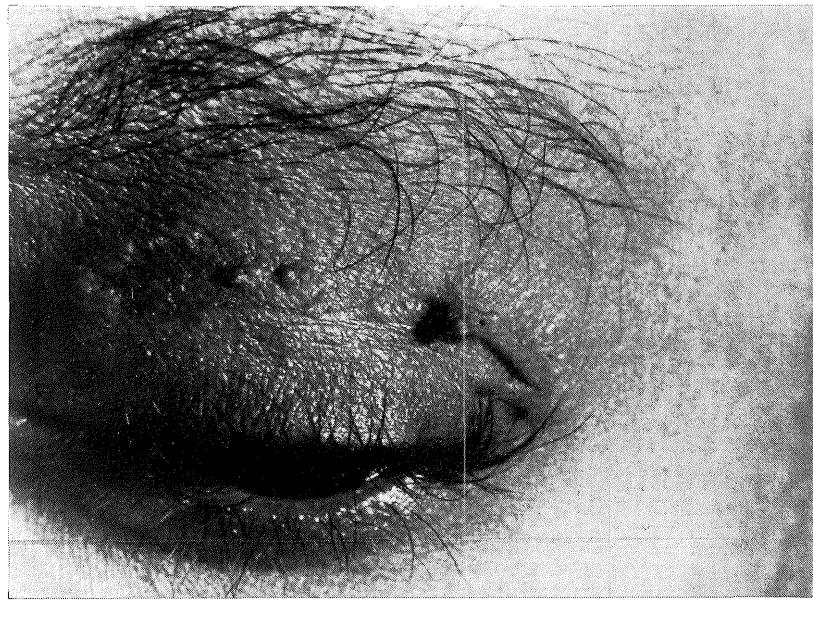


FIG. 38 - Woman from Tamrau Mountain area, showing scarifications in the region of the eyebrow

FIG. 39 - Old scarification, running over almost the full width of the upper eyelid, parallel to the lidmargin. The irregular scar is caused by secondary healing



Summary

Since Western New Guinea until fairly recently has remained a relatively isolated continent and ophthalmological diseases such as trachoma therefore might justifiably be expected to manifest themselves in a 'pure natural history,' an attempt was made to determine as closely as conditions would permit the prevalence, nature and natural course of trachoma and other eye diseases in this area.

To that end, six geographically different regions including coastal mountains, islands, high mountain ranges and swamps, were visited by the author over the years 1961 and 1962. In order to acquaint the reader with the nature of the country of which part of the population was examined, a brief description of each of the regions visited has been given in the Introduction.

Since Western New Guinea is one of the most rugged and inaccessible countries of the world, the most divergent means of transport had to be used during the survey. The method of examination had to remain limited to routine ophthalmological investigation. Examination was carried out with the hand slit-lamp, conjunctival scrapings were taken and photographic documentation was made. Method and procedure have been set out in the Introduction.

A representative sample of the population was examined, based upon a sampling unit, which was defined as all inhabitants of a village hut. A total of 7963 aborigines, being an estimated 1 per cent of the entire Papuan population of Western New Guinea, has been examined.

Trachoma was present in an average of 53% of the individuals examined. The condition ran a very mild course in the majority of cases. The trachomatous process on the upper eyelid is chiefly located at the upper tarsal border and adjacent supratarsal conjunctiva. A more extensive spread of the process is not exceptional, however.

The percentage of active trachoma cases in which tarsal follicles were present ranged from 35 to 86% in the various regions. Scar

formation was in general only slight and usually remained limited to the upper tarsal border and adjacent supratarsal conjunctiva. On the lower eyelid, scar formation developed exceptionally and then only to a slight extent. The pannus prevalence rates in the various districts ranged from 0.3 to 68 per cent of the total number of trachoma cases. The extension of the corneal vascular infiltration usually amounted to only a few millimetres.

Among 4237 cases of trachoma only 1 case of binocular blindness, 1 case of monocular blindness and 6 cases of (mostly monocular) reduced visual acuity resulting from trachoma were observed. These figures are a positive demonstration of the benign nature of trachoma in Western New Guinea.

The average percentage of trachoma in the various regions ranged from 38 to 67 per cent of those examined. The distribution of trachoma prevalence over the various age groups showed identical characteristics in all regions screened. Below the age of 1 year the trachoma prevalence already amounts from 30 to 50 per cent. This strongly suggests trachoma to be a domestic infection. The maximal trachoma prevalence is reached at the age of 2 on the average, followed by a continuous fall in prevalence which is steepest before the age of 20 and gradually flattens out after that age. The fall in prevalence differs markedly in the various districts.

In order to analyze this discrepancy, the prevalence of the different trachoma stages has been determined as well and represented in graphs. Comparison of the prevalence rate curves of the various trachoma stages clearly shows that the prevalence curves of trachoma stages Mac Callan I + II in all regions with advancing age decrease according to a parabolic curve. The Trachoma III prevalence rate curves show only minor variations and the rise of the Trachoma IV prevalence rate curves differs markedly in all regions visited. In addition, it could be shown that the difference in decrease of trachoma prevalence at the advanced ages is largely determined by the percentage of spontaneous cures with sequelae (such as scars or pannus) which differs widely from district to district.

The percentage of total spontaneous cures, which is the percentage of spontaneous cures with restitutio ad integrum, added to the percentage Trachoma IV as present in an advanced age group, in several areas ranged from 64,5 to 79% (expressed as percentages of the maximal prevalence of the pertinent area). This percentage is inde-

pendent of the average trachoma prevalence. The percentage of spontaneous cures which leave no traces is calculated from the difference between maximal and minimal trachoma prevalence rates. It is argued that the age groups with minimal trachoma prevalence are quite likely to contain an unknown number of clinically visible reinfections. Since we have proceeded from the assumption that the maximum prevalence groups (which are those of the first years of life) do not contain reinfection cases, the calculated percentages of total spontaneous cures are to be regarded as *minimum* percentages.

A total of 302 conjunctival smears was made for diagnostic purposes. This explains why they have come mainly from cases in the follicular stage without either pannus or scar formation. In 60% the smears were positive for inclusions. Those smears which had been obtained from either normal eyes or eyes showing slight papillary hypertrophy only, were also positive for inclusions in resp. 60 and 40% of the cases. This shows beyond doubt the existence of healthy virus carriers.

The distribution of trachoma cases over the sampling units (family units) indicates that in an area with a lower trachoma prevalence, a considerable horizontal distribution of the infection nevertheless is present. For instance, in the Mimika area an average trachoma prevalence of 38% has been established; yet 80% of the family units proved to be infected. An even more striking example than this is found in the Upper-Digul region, in which an average trachoma prevalence of 61% is present. Upon investigation all houses (family units) proved to be infected.

On the basis of these findings the conclusion is drawn that the virus prevalence considerably exceeds the value which one would be inclined to expect from the trachoma prevalence curves.

In all regions the Trachoma I + II prevalence rate curves decrease steadily following a parabolic curve, reaching a value of between 9 and 25% in the age groups 31 to 50 years. Such a constant feature of the Trachoma I + II curves in all regions so highly different from each other, indicates that the same factors underlie the natural course of trachoma anywhere. These factors are inherent to the disease. Environmental influences at best may modify the manner of healing (with or without leaving scars).

After consideration of some epidemiological factors which underlie the spread of an infectious disease within a community, the following conclusion is arrived at: Irrespective of still largely unknown factors such as possible differences between virus strains, the course of the various trachoma prevalence rate curves is determined by the factors infection, re-(super-) infection and immunity. In a certain community in which environmental and living conditions have remained unchanged for a long period of time, this host-virus relationship is balanced. Depending on the intensity of the host-virus circulation this equilibrium may be achieved at different levels, the height of which will influence the clinical character of trachoma, in particular the frequency and extent of scar formation. The height of this level does not, however, influence the tendency of spontaneous healing, as is proved by the near-identical fall of Trachoma I + II prevalence rate curves in areas which diverge widely from an epidemiological point of view.

Changes in environmental and living conditions disturb such an equilibrium. This is illustrated by the course of the trachoma prevalence rate curve of the Upper-Digul region. In this area, the population only very recently changed from a nomadic to a settled way of life, which resulted in an increase of inter-personal contacts. Following this, the increased rapidity of virus passage caused a change in the quantitative relation between host and circulating virus, leading to an increase in prevalence. Continuance of this process is to be expected until a new equilibrium at a different level is established.

The way of living of the aborigines in the various regions affects the percentage of spontaneous cures with restitutio ad integrum in such a manner that this percentage is in inverse ratio to the chances of reinfection and superinfection. In other words, the character of trachoma in a certain region depends on the frequency and intensity of viral re-and super-infections. It goes without saying that other factors, as yet unknown, may co-determine the course of trachoma.

In females, after they have reached the reproductive age, the trachoma prevalence exceeds that of males. This observation is explained by the increased chance of re-(super-) infection because of the intense contact of women with their children. The influence of chronic bacterial super-infections on the course of trachoma could be demonstrated in

the densely populated Schouten Islands where trachoma frequently runs a severe course. This can also be explained by the increased chances of viral re- or super-infections. The data obtained by comparison of the various regions provide strong arguments against the assumption of climate, light, sand, dust or flies having a predominent influence on the course of trachoma in Western New Guinea.

Study of the features of endemic trachoma leads to the conclusion that trachoma in Western New Guinea is a disease with a high degree of infectivity and a low degree of virulence. Into malignant types it changes only when favoured by very poor hygienic conditions, possibly in combination with other factors such as bacterial superinfection.

It is argued that any statement on the malignancy of trachoma based upon clinical data is deceptive, because the symptom-free cases which in many countries constitute the large majority of cases, are not seen by the clinician. Because of this, the clinical concept of trachoma which emphasizes the malignancy of this disease, is incorrect.

Finally some suggestions are made for the planning and policy of mass treatment campaigns. It is stressed that a fundamentally correct knowledge of the real prevalence of trachoma can only be obtained by means of a virus sample survey of a statistically representative sample of the population, including healthy people.

The reasons why general therapeutic measures against trachoma in Western New Guinea are not necessary, are set out. An exception to this is made for the Schouten Islands, where a full investigation has not been carried out for various reasons. The preliminary impression of the Schouten Island population however is that malignant types of trachoma occur frequently. A plea is made for closer study of the situation there.

In Part II the frequency and the causes of blindness in Western New Guinea are dealt with. Excluding the pilot study, only 15 blind people were seen among a total of 7808 individuals. The percentage of monocular blindness amounts to 1.67%. Senile cataract is the most important cause of blindness. Among the causes of blindness trachoma plays a minor role.

The importance of 'preventable diseases,' such as injuries and inflammations in the aetiology of a large number of cases of blindness,

is stressed. Because of the slight chances of survival for blind people, and in particular for blind infants, in a primitive society, the 'preventable diseases' assume a still larger importance than one would be led to infer from the table representing the causes of blindness.

Part III deals with the ocular disorders due to Vitamin A deficiency and with arcus senilis, immature cataract, pterygium, glaucoma and artefacts. Other miscellaneous ocular affections are listed in a table.

The presence of eye-disease, due to Vitamin A deficiency has been established. The make-up and primary goal of our mass screening survey, however, did not allow us to acquire a fuller knowledge of the importance of this disorder.

The prevalence of arcus senilis in the various age groups of the samples of the various regions has been compared. This inter-regional comparison indicated the prevalence in Western New Guinea to be highest in those regions where harsh conditions of life prevail. This is explained by referring to the rapid ageing of the Western New Guinea natives, especially those who are exposed to extremely unfavourable living conditions.

The prevalence of pterygium in the various regions varies considerably. In the Tamrau Mountain population it amounted to 1.5% of the examined individuals of 41 years and over, whereas in the Radja Ampat archipelago the prevalence amounted to 23% of the same age group. The author feels that continuous intensive solar radiation constitutes an important factor in the development of pterygium. Blindness due to ptergygium is present only in individuals over 35 years of age.

Résumé

Attendu que la Nouvelle Guinée Occidentale jusqu'à une période récente était un continent relativement isolé, on pouvait s'attendre à ce que les maladies des yeux, telles que le trachome, se développent selon un décours naturel. Pour cette raison, nous avons fait un effort, autant que les circonstances le permissent, d'étudier et de suivre la nature, la prévalence et le décours normal du trachome et d'autres maladies des yeux dans cette partie du monde.

Pour ce but, six régions géographiquement différentes, comprenantes des régions littorales, des îles, des hautes montagnes et des marais furent visitées par l'auteur aux années 1961 et 1962.

Afin de mettre le lecteur à même de se former une idée de ce continent, dont une partie de la population autochthone fut examinée, nous avons donné dans l'Introduction, une brève description de chaque région.

La Nouvelle Guinée Occidentale est une des terres les plus inhospitalières et les plus impénétrables du monde, dont l'exploration exige des moyens de transport les plus divers et les plus hétéroclites. Cette situation et aussi la nature des recherches exigeaient de se contenter d'un examen ophtalmologique de routine, complété par l'emploi de la lampe à fente à main. En plus, une série de frottis de l'épithélium conjonctival a été préparée ainsi qu'une documentation photographique.

Un spécimen représentatif de la population autochthone, basé sur le soi-disant 'sampling-unit' a été examiné. Par définition, un 'sampling unit' était composé de tous les habitants d'une seule hutte de village. En totalité 7963 indigènes, environ 1 pour cent de toute la population Papoua de la Nouvelle Guinée Occidentale, ont été examinés.

Trachome fut décelé dans 53% des individus examinés. Dans la plupart des cas, la maladie se caractérisait par un décours bénin. A la paupière supérieure le processus trachomateux était principalement

localisé le long du bord profond du tarse et la conjonctive supratarsienne adjacente. Cependant, une plus grande extension de la maladie n'était pas une exception.

Le pourcentage des cas actifs de trachome, où des follicules tarsales furent constatés, variait de 35 à 86% dans les diverses régions visitées. La formation de cicatrices était relativement rare et restait limitée dans la plupart des cas au bord profond du tarse at à la conjonctive supratarsienne adjacente. A la paupière inférieure, la cicatrisation se développait rarement et d'ailleurs à un degré très minimal.

Dans les différentes régions, les pourcentages de prévalence de pannus variaient de 0,3 à 68 pour cent de tous les cas de trachome. Dans la plupart des cas, l'envahissement vasculaire de la cornée ne comporte que quelques millimètres.

Parmi 4237 cas de trachome nous n'avons observé qu'un seul cas de cécité binoculaire, un cas de cécité monoculaire et six cas avec abaissement de l'acuité visuelle la plus souvent unilatérale, à cause du trachome.

Le pourcentage moyen de trachome constaté dans les diverses régions variait de 38 à 67% de la population examinée. Le répartition de la fréquence de trachome parmi les différents groupes d'âge était identique dans les diverses régions.

Dans la première jeunesse, la prévalence de trachome monte déja à 30 à 50%, ce qui présente un argument probant pour considérer le trachome comme infection domestique. La prévalence maximale de trachome se présente vers la 20-ième année, après quoi, dans les âges les plus avancés, une diminution graduelle apparaît, qui est le plus prononcée avant le 20-ième année. Cette diminution de la prévalence de trachome présente des différences considérables suivant les régions examinées. Afin d'analyser ces différences à la manière la plus approfondie, les prévalences des divers stades de trachome furent déterminées et représentées en graphiques. Une comparaison des courbes de pourcentage-prévalence des divers stades de trachome met en évidence que, dans toutes les régions examinées, les courbes de pourcentage-prévalence des stades Mac Callan I + II descendent suivant une courbe parabolique. Entre eux, les courbes de pourcentage-prévalence des stades Mac Callan III ne présentent que des variations minimes; par contre des différences très appréciables se présentent dans les courbes de prévalence Mac Callan IV dans toutes les régions visitées.

En plus, il fut établi que la différence dans la diminution de la pré-

valence de trachome vers l'âge plus avancé est déterminée pour la plus grande partie par le pourcentage des guérisons laissant des traces résiduelles, telles que le pannus ou des cicatrices; il y avait dans ces pourcentages une différence considérable dans les districts divers.

Le pourcentage de toutes les quérisons spontanées, qui était obtenu par l'addition du pourcentage des guérisons spontanées avec 'restitutio ad integrum' au pourcentage Trachome IV (comme constaté dans des groupes d'indigènes plus âgés) variait dans les divers districts de 64,5 à 79 pour cent (exprimé comme pourcentage de la prévalence maximum du trachome dans la région en question). Ce pourcentage est quasi-indépendant de la prévalence moyenne du trachome.

Le pourcentage des guérisons spontanées sans traces résiduelles est déduit de la différence entre le pourcentage maximal et minimal de la prévalence du trachome. Des arguments ont été apportés pour rendre probable que les goupes d'âge avec prévalence minimale de trachome, contiennent très vraisembablement un nombre inconnu de réinfections cliniquement manifestes. Attendu que l'on suppose que les groupes de la population avec prévalence maximale (donc ceux de première jeunesse) ne comprennent pas de cas de réinfection, les pourcentages calculés de guérison spontanée totale doivent être considérés comme pourcentages minimums.

Pour buts diagnostiques on a pris un total de 302 frottis conjonctivales. Ceci explique pourquoi leur origine provient pour la majorité des cas en stade folliculaire sans pannus ni cicatrisation. On a trouvé des inclusions dans 60% des frottis. Dans resp. 60 et 40% des frottis qui étaient pris des conjonctives normales ou des conjonctives atteintes d'une minime hypertrophie papillaire, on a trouvé des inclusions.

La répartition des cas de trachome dans les 'sampling-units' (unités familiales) semble indiquer aussi que dans une région où la prévelence de trachome est plus basse, il existe néanmoins une importante diffusion horizontale de l'infection. Il en est ainsi, par exemple dans la région du Mimika, où la prévalence moyenne de trachome est de 38%; il se trouve cependant que 80% des unités familiales étaient infectées. Un exemple encore plus frappant forme le région du Haut-Digul, où la prévalence de trachome s'augmente jusqu'a 61%. On a établi que toutes les huttes (unités familiales) étaient contagionnées.

Se basant sur ces résultats on doit conclure que la prévalence de virus surpasse largement la valeur que l'on serait tenté d'attendre en se basant sur les courbes de la prévalence de trachome.

Dans toutes les régions visitées les courbes de prévalence de trachome I + II descendent régulièrement selon une parabole, et finissent par atteindre une valeur entre 9 et 25% dans les groupes d'âge de 31-50 ans. Une pareille caractéristique constante des courbes de trachome I + II dans toutes ces régions, qui diffèrent cependant si fortement entre elles, indique que les mêmes facteurs influencent le décours naturel du trachome. Ces facteurs sont inhérents à la maladie, les influences du milieu ne modifiant que le mode de guérison (c.-à.-d., avec ou sans cicatrisation).

Après avoir mentionné un nombre de facteurs épidémiologiques, qui sont à la base de la propagation d'une maladie contagieuse dans une communauté, on a tiré les conclusions suivantes.

En laissant de côté un nombre de facteurs largement inconnus, tels que des différences possibles entre des souches de virus, la configuration des différentes courbes de prévalence de trachome est déterminée par les facteurs infection, ré-(super-)infection et immunité. Sans une communauté quelconque, où le milieu et la mode de vie n'avaient subi aucun changement pendant de longues périodes, la relation entre l'hôte et le virus reste en équilibre. Dépendant de l'intensité de circulation du virus cet équilibre peut s'établir à des niveaux différents dont la hauteur détermine le caractère clinique du trachome comme, en particulier, la fréquence et l'étendue de la cicatrisation. Cependant, la hauteur de ce niveau n'influence pas la tendance à une guérison spontanée. Ceci est prouvé par la quasi-identité de baisse de la courbe de prévalence Trachome I + II, provenant des régions qui, au point de vue épidémiologique, diffèrent considérablement l'une de l'autre.

Des changements apportés dans le milieu et dans la manière de vivre rompent l'équilibre mentionné plus haut. Le tracé de la courbe de prévalence de trachome de la région du Haut-Digul illustre ce fait. Dans cette région, la population n'est passée que tout récemment de la vie nomade à la vie domiciliée ce qui amenait une augmentation des contacts inter-individuels. Par conséquence, la vitesse circulatoire virale augmentée causait un tel changement dans la relation entre hôte et virus en circulation, que la courbe de prévalence de trachome s'élevait. On doit s'attendre à une continuation de ce processus, jusqu'à ce qu'un nouvel équilibre sur un autre niveau soit atteint.

La mode de vie des indigènes dans les différentes régions influence de telle façon le pourcentage de guérisons spontanées avec 'restitutio ad integrum', que ce pourcentage est inversement proportionnel au risque de réinfection et de superinfection. En d'autres mots, le caractè-

re du trachome dans une certaine région dépend de la fréquence et de l'intensité de la réinfection et superinfection virale. Il va de soi que d'autres facteurs, actuellement encore inconnus, peuvent influencer également le décours du trachome.

Après la puberté, la prévalence de trachome est plus élevée chez les femmes que chez les hommes. Cette observation s'explique par le fait que le risque de réinfection et de superinfection chez elles est devenu plus grand, parce qu'en cette période de l'existence il y a un contact intensif entre les femmes et leurs enfants. L'influence de superinfection bactérielle chronique sur le décours du trachome a été démontrée par l'observation que dans les îles surpeuplées de Schouten, le trachome montre un caractère malin. L'explication de cette constatation est donnée par les risques augmentés de réinfection et de superinfection virale. Les données, qui ont été obtenues par la comparaison des différentes régions, s'opposent fortement à une influence du climat, de la lumière ou de la poussière sur le développement et le décours du trachome en Nouvelle Guinée Occidentale. L'étude des caractéristiques du trachome endémique amène la conclusion qu'en Nouvelle Guinée Occidentale, le trachome est une maladie extrêmement infectieuse mais à faible virulence. Le trachome change son caractère bénin en forme maline dans de mauvaises conditions hygiéniques, allant de pair avec d'autres facteurs, tels que des superinfections bactériologiques.

Des arguments ont été apportés suggérant que tout avis concernant la malignité de trachome basé sur des expériences cliniques, est trompeux puisque des cas ne présentant aucun symptome (qui, dans nombre de pays, constituent la majorité des cas de trachome) ne parviennent pas à la portée d'examens cliniques. Donc la conception clinique du trachome, laquelle souligne la malignité de cette maladie, n'est pas exacte.

On a discuté les raisons, pourquoi des mesures thérapeutiques générales ne sont pas nécessaires en Nouvelle Guinée Occidentale. Sur ce point on doit faire une exception pour les îles Schouten, où des recherches complètes n'ont pu avoir lieu. Nous avons seulement obtenu une impression provisoire du trachome des indigènes de ces îles; des formes malignes semblaient se présenter avec fréquence. Par conséquence, la situation dans ces îles exige une étude plus approfondie.

Dans la III-ième partie on a traité les causes et la prévention de la

cécité en Nouvelle Guinée Occidentale. Parmi le nombre de 7808 individus, nous n'avons observé que 15 aveugles. Le pourcentage de borgnes se montait à 1,67%. La cause la plus importante de la cécité est la cataracte sénile; le trachome ne prend qu'une place limité parmi les autres causes de ce mal.

L'importance des blessures et des inflammations dans l'étiologie d'un nombre de cas de cécité est accentuée. Les chances de survie des aveugles, et spécialement des enfants aveugles, étant minimes dans ces communautés primitives, cette catégorie des maladies ophtalmiques a beaucoup plus d'importance que ce qu'on est tenté de conclure de la table relative aux causes.

Dans la partie III nous avons traité successivement les conditions ophtalmiques par hypovitaminose A, l'arc sénile, la cararacte immature, le ptérygium, le glaucome et les artefaits. D'autres maladies des yeux ont été recueillies dans une table spéciale.

La présence des maladies des yeux par hypovitaminose A en Nouvelle Guinée Occidentale a été établie. La nature et le but principal de notre investigation de la population ne permit toutefois pas d'obtenir une connaissance plus approfondie de l'importance de ces conditions.

La prévalence d'arc sénile a été comparée chez différents groupes d'âge des 'samples' des différentes régions. Cette manière de comparaison interrégionale a permis de montrer que l'arc sénile se présentait le plus souvent en Nouvelle Guinée Occidentale dans les régions où les conditions d'existence étaient les plus misérables. L'explication de l'apparition précoce d'arc sénile est amenée par le vieillissement généralement précoce de la population des régions en question, et ceci en particulier chez les indigènes qui doivent exister dans des conditions extrêmement défavorables.

Les prévalences de ptérygium se varient considérablement dans les diverses régions: parmi la population des monts Tamrau le ptérygium a été constaté dans 1,5% du total des autochthones âgés de plus de 40 ans, tandis que dans l'archipel Radja Ampat le pourcentage du groupe du même âge s'élevait à 23%.

L'exposition prolongée au soleil brillant semble être un facteur très important dans le développement du ptérygium. La cécité due au ptérygium a uniquement été constatée chez des individus d'un âge de plus de 35 ans.

Samenvatting

Daar Westelijk Nieuw Guinea tot voor kort betrekkelijk geïsoleerd was, kon men verwachten dat oogziekten, zoals trachoom, zich manifesteren in een natuurlijk verloop. Zo nauwkeurig mogelijk als de omstandigheden dit toelieten werd getracht de prevalentie, de aard en het verloop van trachoom en andere oogziekten in Westelijk Nieuw Guinea na te gaan. Daartoe werden zes geografisch sterk verschillende gebieden, bestaande uit kuststreken, eilanden, hooggebergten en moerassen, in de jaren 1961 en 1962 door de schrijver bezocht.

Teneinde de lezer een indruk te geven van deze gebieden, waar een deel van de bevolking werd onderzocht, wordt hiervan in de Inleiding een beschrijving gegeven. Westelijk Nieuw Guinea is een van de meest onherbergzame en ontoegankelijke delen ter wereld. Hierdoor konden de gebieden, welke werden onderzocht, slechts worden bereikt met behulp van transportmiddelen van de meest uiteenlopende soort. Deze omstandigheid, benevens de aard van het onderzoek, bracht met zich mede dat moest worden volstaan met een oogheelkundig routine-onderzoek, dat gecomplementeerd werd door onderzoek met de handspleetlamp. Tevens werden conjunctiva afschraapsels gemaakt en werden afwijkingen fotografisch gedocumenteerd.

Onderzocht werd een representatief monster van de bevolking, gebaseerd op een zogenaamde 'sampling-unit.' Per definitie werd een sampling-unit gevormd door alle bewoners van één kamponghut. In totaal werden 7963 autochthonen onderzocht; dit is ongeveer 1 procent van de gehele Papoea bevolking van Westelijk Nieuw Guinea. De methode van onderzoek en de gevolgde procedure worden beschreven in de Inleiding.

In Deel 1 wordt trachoom behandeld. Dit is de meest frequent voorkomende oogaandoening. Zij werd gediagnostiseerd bij gemiddeld

53% der onderzochte personen. Deze aandoening vertoont in de overgrote meerderheid der gevallen een zeer goedaardig karakter.

Aan het bovenooglid is het trachomateuze proces voornamelijk gelocaliseerd langs de bovenste tarsusrand en de aangrenzende supratarsale conjunctiva. Verdere uitbreiding van het proces is echter niet zeldzaam. Het percentage trachoomgevallen dat tarsale follikels vertoont, varieert in de verschillende gebieden van 35 tot 86% van de actieve trachoomstadia (Mac Callan I-III).

Littekenvorming is over het algemeen gering en blijft meestal beperkt tot de bovenste tarsusrand en de aangrenzende supratarsale conjunctiva. In het onderooglid is littekenvorming steeds zeer gering en vaak ook afwezig. In de verschillende gebieden varieert het aantal gevallen van trachoom waarbij pannus aanwezig is, van 0,3 tot 68% van het totale aantal onderzochte trachoomgevallen van het betreffende gebied. De lengte van de corneale vaatingroei bedraagt over het algemeen slechts enkele millimeters. Bij 4237 trachoomgevallen werden slechts 1 geval van blindheid, 1 geval van monoculaire blindheid en 6 gevallen van meestal monoculair verminderde visus waargenomen. Deze getallen demonstreren duidelijk het goedaardige karakter van het trachoom in Westelijk Nieuw Guinea.

De trachoomprevalentie varieert in de verschillende gebieden van 38 tot 67%. De verdeling van de trachoomprevalentie over de verschillende leeftijdsgroepen vertoont in alle onderzochte gebieden dezelfde karakteristiek.

In het eerste levensjaar bedraagt de trachoomprevalentie reeds 30 tot 50 procent, hetgeen een argument vormt om trachoom als huisinfectie te beschouwen. De maximum prevalentie wordt gemiddeld reeds op 2-jarige leeftijd bereikt, waarna een geleidelijke daling optreedt, welke het sterkst is vóór de leeftijd van 20 jaar. In de genoemde gebieden vertonen de dalingen van de trachoomprevalenties onderling grote verschillen. Teneinde deze verschillen te analyseren worden de prevalentiecurven van de verschillende trachoomstadia met elkaar vergeleken. Hieruit blijkt, dat in alle gebieden met het voortschrijden van de leeftijd de prevalenties van de stadia Mac Callan I + II dalen volgens een parabolische curve. De stijging van de Trachoma IV prevalentiecurven verschilt daarentegen sterk van gebied tot gebied, terwijl de Trachoma III prevalentiecurven onderling slechts geringe variaties vertonen.

Het tussen de onderzochte gebieden aanwezige verschil in daling van de trachoomprevalentie op oudere leeftijd wordt grotendeels bepaald door de van gebied tot gebied aanzienlijk verschillende percentages van spontane genezingen met achterlating van restverschijnselen, zoals pannus of littekens.

Het percentage totale spontane genezingen, dat wordt verkregen door het percentage spontane genezingen met restitutio ad integrum te vermeerderen met de Trachoma IV prevalentie van een oudere leeftijdsgroep, varieert in de verschillende gebieden van 61 tot 79% (uitgedrukt als percentage van de maximum trachoomprevalentie van het betreffende gebied). Het percentage totale spontane genezingen is onafhankelijk van de gemiddelde trachoomprevalentie.

Het percentage spontane genezingen zonder achterlating van restverschijnselen varieert van 25,9 tot 68,2%. Dit is berekend uit het verschil tussen maximale en minimale trachoomprevalentie van het betreffende gebied.

Uiteengezet wordt dat de berekende percentages totale spontane genezingen steeds moeten worden beschouwd als minimum percentages.

Voor diagnostische doeleinden werden in totaal 302 bruikbare conjunctiva afschraapsels gemaakt. Deze zijn derhalve grotendeels afkomstig van trachoomgevallen in het folliculaire stadium zonder pannus of littekenvorming. In 60% van de afschraapsels werden insluitlichaampjes gevonden. Afschraapsels van normale conjunctivae en van conjunctivae, welke slechts een lichte papillaire hypertrophie vertoonden, waren positief op insluitsels in 60 resp. 40%. Het bestaan van gezonde virus carriers is hiermede aangetoond.

De verdeling van trachoomgevallen over de familie-eenheden (sampling-units) wijst uit dat in een gebied met een lagere trachoomprevalentie eveneens een aanzienlijke horizontale spreiding van de infectie aanwezig is. Zo bedraagt bijvoorbeeld in het Mimika gebied de gemiddelde trachoomprevalentie 38%; nochtans bleken 80% van de sampling-units klinisch geïnfecteerd. Een nog duidelijker voorbeeld is het Boven-Digul gebied waar een gemiddelde trachoomprevalentie van 61 aanwezig is. Hier bleken alle sampling-units klinisch geïnfecteerd.

Op grond van deze bevindingen moet worden geconcludeerd dat de virusprevalentie belangrijk hoger is dan de trachoomprevalentiecurven doen vermoeden.

Na de maximum prevalentie daalt in alle gebieden de Trachoom I + II prevalentie volgens een parabolische curve, totdat in de leeftijdsgroep 31-50 jaar een waarde liggend tussen 9 en 25% bereikt is. Een dergelijk verloop van de Trachoom I + II prevalentiecurven van alle onderling zo sterk verschillende gebieden vormt een aanwijzing, dat overal dezelfde factoren aan het natuurlijke verloop van trachoom ten grondslag liggen. Deze factoren zijn aan de ziekte inhaerent; milieu-invloeden modificeren de wijze van genezing, nl. met of zonder littekenvorming. Afgezien van nog onbekende factoren, zoals mogelijke verschillen tussen virusstammen, wordt het verloop van de verschillende trachoomprevalentiecurven bepaald door de factoren infectie, re-(super-)infectie en immuniteit. In een milieu waar constante levensomstandigheden aanwezig zijn vormen deze met elkaar een evenwicht. Afhankelijk van de intensiteit van de viruscirculatie kan dit evenwicht zich instellen op verschillende niveaus. De hoogte van dit niveau bepaalt het klinische karakter van trachoom, met name de mate van littekenvorming. (In dichter bevolkte gebieden is littekenvorming sterker uitgesproken dan in dunbevolkte gebieden). Deze hoogte is echter niet van invloed op de spontane genezingstendens van het proces, zoals blijkt uit de vrijwel identieke daling van de Trachoom I + II prevalentiecurven in epidemiologisch sterk verschillende gebieden.

Veranderingen in milieu- en levensomstandigheden verstoren bovengenoemd evenwicht. Dit blijkt uit het verloop van de trachoomprevalentiecurve van het Boven-Digul gebied. In dit gebied is de bevolking eerst in zeer recente tijd overgegaan van een nomadische levenswijze naar een bestaan in vaste nederzettingen. De bestaande evenwichtsverhoudingen werden hierdoor verstoord, in die zin dat door de toegenomen contactmogelijkheden de quantitatieve relatie tussen gastheer en circulerend virus werd gewijzigd. Dit resulteert in een stijgende prevalentie, totdat een nieuw evenwicht op een ander niveau is bereikt.

Het percentage spontane genezingen met restitutio ad integrum wordt door de levenswijze van de autochthone bevolking zodanig beïnvloed, dat genoemd percentage groter is naarmate de re- (super-) infectiekansen geringer zijn, met andere woorden: in een bepaald gebied is het karakter van het trachoom afhankelijk van de frequentie en mogelijk ook van de intensiteit van virale re- (super-) infecties.

De invloed van chronische bacteriële superinfecties op het verloop van het trachomateuze proces kon worden aangetoond op de dichtbevolkte Schouten Eilanden. Hier is overwegend trachome mixte aanwezig en komen ernstige vormen van trachoom voor. Genoemde invloed op het verloop van het trachomateuze proces kan eveneens worden verklaard door verhoogde virale re- (super-) infectiekansen.

Bij het vrouwelijk geslacht is vanaf de reproductieve leeftijd de trachoomprevalentie hoger dan bij mannen. Deze waarneming wordt verklaard door hogere re- (super-) infectie-kansen tengevolge van intensievere contacten van vrouwen met kinderen.

Vergelijking van de verschillende gebieden leidt tot de conclusie dat klimatologische omstandigheden, licht, zand, stof en de aanwezigheid van vliegen, niet van invloed zijn op het verloop van trachoom in Nieuw Guinea.

Bestudering van endemisch trachoom leidt tot de conclusie dat trachoom een ziekte is met een hoge infectiositeit en een lage virulentie. Slechts onder zeer ongunstige hygiënische omstandigheden en eventueel in combinatie met andere factoren, zoals bacteriële superinfecties, kan trachoom ontaarden in maligne vormen. Indrukken over de maligniteit van trachoom welke gebaseerd zijn op gegevens uit klinieken kunnen slechts misleidend zijn, daar de symptoomloos verlopende gevallen, welke in vele landen de overgrote meerderheid der gevallen uitmaken, niet onder de aandacht van de clinicus komen. Het klinische concept, dat zozeer de nadruk legt op de maligniteit van trachoom, is derhalve niet juist.

Tenslotte worden enkele richtlijnen voorgesteld voor de te volgen procedure bij trachoombestrijdingscampagnes. Voorop wordt gesteld, dat een juist inzicht in de werkelijke verspreiding van trachoom slechts kan worden verkregen door een virus sample onderzoek bij een representatief sample van de bevolking, inclusief de gezonden.

Het nemen van algemeen therapeutische maatregelen is in de meeste gebieden van Westelijk Nieuw Guinea niet noodzakelijk. Een mogelijke uitzondering dient echter voor de Schouten Eilanden te worden gemaakt, waar om verschillende redenen geen volledig onderzoek heeft kunnen plaatsvinden. De voorlopige indrukken van de schrijver wijzen erop, dat in dit gebied maligne trachoomvormen frequent voorkomen. Een nadere bestudering van de situatie is hier gewenst.

In Deel II worden het voorkomen en de oorzaken van blindheid in Westelijk Nieuw Guinea behandeld. Tijdens het bevolkingsonderzoek werden slechts 15 blinden waargenomen. De prevalentie van monoculaire blindheid bedraagt 1,67%. De belangrijkste oorzaak van blindheid is cataracta senilis. Onder de oorzaken van blindheid neemt trachoom slechts een ondergeschikte plaats in.

Er wordt op gewezen dat een groot aantal gevallen van blindheid wordt veroorzaakt door traumata en ontstekingen. Omdat in primitieve samenlevingen de overlevingskansen van blinden, en met name van blinde jonge kinderen, bijzonder gering zijn, is blindheid tengevolge van traumata en ontstekingen in werkelijkheid veel belangrijker dan men geneigd is af te leiden uit tabel 3, welke de blindheidsoorzaken in volgorde van belangrijkheid weergeeft.

In Deel III worden achtereenvolgens behandeld de oogafwijkingen tengevolge van vitamine A deficientie, arcus senilis, cataracta immatura, pterygium, glaucoom en artefacten in de omgeving van het oog. Andere oogafwijkingen zijn vermeld in tabelvorm.

Oogafwijkingen tengevolge van vitamine A deficiëntie komen in Westelijk Nieuw Guinea voor. De algemene opzet van het onderzoek bracht echter met zich mede, dat geen volledig inzicht in de belangrijkheid van deze aandoening kon worden verkregen.

Interregionale vergelijking van de prevalentie van arcus senilis wijst uit, dat deze bij overeenkomstige leeftijdsgroepen het hoogst is in die gebieden, waar de bevolking onder de ongunstigste omstandigheden leeft. Het vroegtijdig optreden van arcus senilis kan hier dienen als een objectieve maatstaf voor de aanwezigheid van een algemeen vroegtijdig optredend verouderingsproces dat het sterkst op de voorgrond treedt bij die bevolkingsgroepen, welke onder extreem ongunstige omstandigheden leven.

De prevalentie van pterygium vertoont aanzienlijke verschillen in de onderzochte gebieden: bij de bevolking van het Tamrau-gebergte komt pterygium bij 1,5% van het aantal onderzochte personen boven de 40 jaar voor, terwijl in de Radja Ampat Archipel dit percentage voor dezelfde leeftijdsgroep 23% bedraagt. De schrijver komt tot de conclusie, dat continue felle zonnestraling een belangrijke factor voor de ontwikkeling van pterygium vormt. Blindheid tengevolge van pterygium werd uitsluitend waargenomen bij personen ouder dan 35 jaar.

Addendum

In the tables the figures are listed on which among others the graphs in Part I are based.

The following abbreviations are used:

F: presence of follicles, pre-follicles or diffuse trachomatous infiltration.

P: presence of pannus.

Sc: presence of trachomatous scar formation.

TABLE 7 - Sentani Lake area

Places visited	Number of individuals examined	Number of trachoma cases	Percentage of trachoma
Dojo	99	35	35
Jakonde	80	40	50
Kwadeware	48	21	44
Dondai	73	36	49
Babrongko-Semporo	99	55	56
Pujoh-Ketjil	101	56	55
Ifar-Besar	130	58	45
Ifar-Ketjil	106	61	58
Ifar-Babrongko	80	47	59
Jobeh	73	45	62
Jabuai	116	71	61
Sehreh	26	5	19
Total	1031	530	51

TABLE 8 - Sentani Lake area

Sex and age distribution of individuals examined

Age	Males	Females	Total
0			28
1	26	15	41
2	20	15	35
3	28	20	48
4	22	18	40
5	25	23	48
6	19	16	35
7	19	19	38
8	25	26	51
9	11	19	30
10	16	17	33
11-15	48	36	84
16-20	26	30	56
21-30	86	102	188
31-40	59	61	120
41-50	58	45	103
51-60	28	19	47
61-	3	3	6
Total			1031

TABLE 9 - Sentani Lake area. Signs of trachoma according to age and sex.

AGE	F		F+P		Mc.C. I+II		Mc.C. I+II	F+Sc		F+P+Sc		Mc.C. III		Mc.C. III	P		Sc		P+Sc		Mc.C. IV		Mc.C. IV	Total trachoma	% trachoma
	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	♂	♀	total		
0	9				9		9								1						1		1	10	36
1	11	6	5	4	16	10	26																	26	68
2	10	5	5	5	15	10	25		1				1	1										26	
3	9	10	8	4	17	14	31																	31	68
4	5	4	8	11	13	15	28								1						1		1	29	
5	5	8	8	7	13	15	28						1	1		1						1	1	30	67
6	4	3	8	11	12	14	26																	26	
7	4	1	5	12	9	13	22		1	1		1	1	2		2			1	1	1	3	4	28	65
8	6	5	6	10	12	15	27				1		1	1	1	1					1	1	2	30	
9	1	3	3	10	4	13	17		1				1	1	1						1		1	19	61
10	2	2	3	7	5	9	14			1		1		1	2	3			1		3	3	6	21	
11-15	6	2	10	11	16	13	29	1			1	1	1	2	7	5			1	1	8	6	14	45	54
16-20	1	2	2	7	3	9	12				1		1	1	3	12		1			3	13	16	29	52
21-30	1	7	11	20	12	27	39	1		1	6	2	6	8	7	15	3	3	1	5	11	23	34	81	43
31-40	2		4	8	6	8	14			2	11	2	11	13	6	3	2	1	3	4	11	8	19	46	38
41-50	2			5	2	5	7	1	3	3	4	4	7	11	3	2	3	3	3	5	9	10	19	37	36
51-60	1	1			1	1	2	1		1	2	2	2	4	1	2	2	2	1	1	4	5	9	15	32
61-																	1				1		1	1	
																						Total		530	51

TABLE 10 - Wissel Lake area

Places visited	Number of individuals examined	Number of trachoma cases	Percentage of trachoma
Epauto	186	115	62
Enarotali	407	268	66
Kuguapa	80	59	74
Timida	34	25	74
Waghete	326	174	53
Total	1033	641	62

TABLE 11 - Wissel Lake area

Sex and age distribution of individuals examined			
Age	Males	Females	Total
0			45
1	27	16	43
2	14	15	29
3	13	13	26
4	16	11	27
5	17	8	25
6	19	8	27
7	15	6	21
8	27	2	29
9	19	2	21
10	24	7	31
11-15	123	32	155
16-20	110	60	170
21-30	142	136	278
31-40	47	46	93
41-	8	5	13
Total			1033

TABLE 12 - Wissel Lake area. Signs of trachoma according to age and sex.

AGE	F		F+P		Mc.C. I+II		Mc.C. I+II	F+Sc		F+P+Sc		Mc.C. III		Mc.C. III	P		Sc		P+Sc		Mc.C. IV		Mc.C. IV	Total trachoma	% trachoma
	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	♂	♀	total		
0	23				23		23																	23	51
1	21	7			21	7	28																	28	69
2	12	10			12	10	22																	22	
3	10	9			10	9	19																	19	81
4	15	9			15	9	24																	24	
5	14	7			14	7	21	1				1		1										22	81
6	10	7			10	7	17	2	1			2	1	3										20	
7	6	4			6	4	10	3				3		3										13	68
8	17	1			17	1	18	2	1			2	1	3										21	
9	6				6		6	7		1		8		8			1	1			1	1	2	16	65
10	7	3			7	3	10	8				8		8										18	
11-15	41	17			41	17	58	23	8			23	8	31			8	1			8	1	9	98	63
16-20	21	14	1		22	14	36	20	14			20	14	34			18	5			18	5	23	93	55
21-30	11	31			11	31	42	12	27			12	27	39			53	27			53	27	80	161	58
31-40	1	8			1	8	9	7	4			7	4	11			16	17			16	17	33	63	59
41-		2				2	2	2	1			2	1	3			4	1			4	1	5		
																							Total	641	62

TABLE 13 - Mimika region

Places visited	Number of individuals examined	Number of trachoma cases	Percentage of trachoma
Kokonao	186	61	33
Uta-Amar	165	53	32
Paripi-Jaraja	167	90	54
Ipiri	244	114	47
Atuka	208	72	35
Aika-Wapuka	200	82	41
Mware	214	86	40
Pigapu	177	48	27
Timika	260	93	36
Total	1821	699	38%

TABLE 14 - Mimika region

Sex and age distribution of individuals examined

Age	Males	Females	Total
0			55
1	39	35	74
2	32	30	62
3	54	38	92
4	37	29	66
5	41	31	72
6	32	26	58
7	22	24	46
8	32	35	67
9	19	25	44
10	12	15	27
11-15	76	89	165
16-20	56	82	138
21-30	138	156	294
31-40	155	153	308
41-50	95	82	177
51-60	32	33	65
61-	7	4	11
Total			1821

TABLE 15 - Mimika region. Signs of trachoma according to age and sex.

AGE	F		F+P		Mc.C. I+II		Mc.C. I+II	F+Sc		F+P+Sc		Mc.C. III		Mc.C. III	P		Sc		P+Sc		Mc.C. IV		Mc.C. IV	Total trachoma	% trachoma
	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	♂	♀	total		
0	16				16		16																	16	29
1	21	20			21	20	41																	41	63
2	22	22			22	22	44																	44	
3	27	26	2	1	29	27	56																	56	59
4	19	14		3	19	17	36								1						1		1	37	
5	16	17	3	1	19	18	37																	37	56
6	17	14	4	1	21	15	36																	36	
7	12	13		1	12	14	26								1						1		1	27	62
8	17	20	3	1	20	21	41	1			1	1	1	2										43	
9	9	5	2	2	11	7	18											1				1	1	19	49
10	5	7	1	1	6	8	14									1	1				1	1	2	16	
11-15	28	27	3	10	31	37	68		3	1		1	3	4		6	1	1			1	7	8	80	48
16-20	7	17		3	7	20	27	1	1		1	1	2	3	4	3	2	1		1	6	5	11	41	30
21-30	15	32	3	1	18	33	51	3	5	1	1	3	6	9	1	6	2	6			3	12	15	75	26
31-40	16	27	1	7	17	34	51	2	4		1	2	5	7	3	4	9	7		1	12	12	24	82	27
41-50	7	10		1	7	11	18	3	1		1	3	2	5	2	1	1	6	1	1	4	8	12	35	20
51-60		5		1		6	6				1		1	1			3	3			3	3	6	13	20
61-																				1		1	1	1	
																							Total	699	38

TABLE 16 - Radja Ampat archipelago

Places visited	Number of individuals examined	Number of trachoma cases	Percentage of trachoma
Meoskapal	124	91	73
Pulau Tikus	29	23	79
Waigama	183	90	49
Fakal	86	42	49
Atkari	51	31	61
Limalas	143	108	76
Tomolol	102	60	59
Jellu	79	54	68
Fanfanlap	179	160	89
Biga	123	66	54
Lilintah	106	84	79
Tolobi	74	61	82
Dibalol	116	61	53
Deer	127	92	72
Total	1522	1023	67%

TABLE 17 - Radja Ampat archipelago

Sex and age distribution of individuals examined

Age	Males	Females	Total
0			35
1	27	26	53
2	26	19	45
3	28	19	47
4	43	17	60
5	36	19	55
6	43	26	69
7	21	4	25
8	17	27	44
9	14	7	21
10	24	8	32
11-15	72	64	136
16-20	65	62	127
21-30	123	130	253
31-40	138	127	265
41-50	88	59	147
51-60	46	37	83
61-	17	8	25
Total			1522

TABLE 18 - Radja Ampat archipelago

AGE	F		F+P		Mc.C. I+II		Mc.C. I+II	F+Sc		F+P+Sc		Mc.C. III		Mc.C. III	P		Sc		P+Sc		Mc.C. IV		Mc.C. IV	Total trachoma	% trachoma
	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	♂	♀	total		
0	13		1		14		14																	14	40
1	19	15	1		20	15	35																	35	70
2	17	11	3	1	20	12	32			1		1		1	1						1		1	34	
3	18	11	5	6	23	17	40																	40	79
4	24	10	4	4	28	14	42	3				3		3										45	
5	21	8	3	6	24	14	38	2		2		4		4			1				1		1	43	81
6	27	9	1	11	28	20	48				1		1	1	1	2	4			1	5	3	8	57	
7	10	3	2	1	12	4	16			1	1	1	1	2										18	75
8	8	9	2	9	10	18	28		1		2		3	3	1		1			1	2	1	3	34	
9	10	1	2	1	12	2	14				1		1	1										15	77
10	10	5	2		12	5	17	2		1	1	3	1	4	2		1	1		1	3	2	5	26	
11-15	28	17	8	20	36	37	73	3	2	3	4	6	6	12	3	4	3	2	5	1	11	7	18	103	76
16-20	11	15	2	7	13	22	35	6	3	4	5	10	8	18	4	8	9	1	6	2	19	11	30	83	65
21-30	18	18	3	13	21	31	52	9	8	2	6	11	14	25	9	15	19	15	13	10	41	40	81	158	62
31-40	13	19	8	9	21	28	49	7	10	6	9	13	19	32	12	4	24	20	12	7	48	31	79	160	60
41-50	9	7	1		10	7	17	4	7	1	4	5	11	16	12	5	14	8	10	6	36	19	55	88	60
51-60	2	3	1		3	3	6	2	3	2	4	4	7	11	5	5	8	7	6	5	19	17	36	53	64
61-	1		1	1	2	1	3								4		2	2	2	4	8	6	14	17	68
																							Total	1023	67

TABLE 19 - Upper-Digul region

Places visited	Number of individuals examined	Number of trachoma cases	Percentage of trachoma
Okwamoeop	181	122	67
Kali Wet	200	124	62
Jauta	49	31	63
Kali Win	152	94	61
Waghabang	144	83	58
Omba-Toetainom	154	99	64
Anggai	156	109	70
Aridua	122	61	50
Getentiri	193	116	60
Aiwat	106	49	46
Total	1457	888	61%

TABLE 20 - Upper-Digul region

Sex and age distribution of individuals examined

Age	Males	Females	Total
0			37
1	20	16	36
2	21	19	40
3	31	22	53
4	35	23	58
5	28	43	71
6	15	30	45
7	30	35	65
8	24	21	45
9	18	10	28
10	15	7	22
11-15	84	58	142
16-20	92	68	160
21-30	134	198	332
31-40	113	92	205
41-50	48	48	96
51-	11	11	22
Total			1457

TABLE 21 - Upper-Digul region

AGE	F		F+P		Mc.C. I+II		Mc.C. I+II	F+Sc		F+P+Sc		Mc.C. III		Mc.C. III	P		Sc		P+Sc		Mc.C. IV		Mc.C. IV	Total trachoma	% trachoma
	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	♂	♀	total		
0	11				11		11																	11	30
1	15	10			15	10	25																	25	79
2	18	17			18	17	35																	35	
3	26	18			26	18	44																	44	77
4	26	16			26	16	42																	42	
5	17	23		2	17	25	42		2				2	2										44	59
6	7	15			7	15	22		1				1	1	1						1		1	24	
7	12	17	1	2	13	19	32	1	1			1	1	2			1				1		1	35	54
8	8	9		1	8	10	18	1	2			1	2	3	1		2				3		3	24	
9	7	5			7	5	12				1		1	1	2		1				3		3	16	52
10	6	2			6	2	8	1	1			1	1	2										10	
11-15	29	19	3	1	32	20	52	12	1	3		15	1	16	1	3	5	4			6	7	13	81	57
16-20	16	19	2	2	18	21	39	14	7	3	2	17	9	26	4	1	18	6	2		24	7	31	96	60
21-30	18	56	3	3	21	59	80	22	22	4	2	26	24	50	4	4	22	27	4	2	30	33	63	193	58
31-40	14	21	5	1	19	22	41	26	11	4	1	30	12	42	3		20	19	5	2	28	21	49	132	64
41-50	6	15	1	1	7	16	23	13	8			13	8	21			10	5	2	1	12	6	18	62	65
51-60	2	2			2	2	4	2	1	1				4		1	2	1		2	2	4	6	14	64
61-																									
																							Total	888	61

TABLE 22 - Tamrau Mountains

Places visited	Number of individuals examined	Number of trachoma cases	Percentage of trachoma
Suru	85	55	65
Damambok	81	19	23
Dambron	67	24	36
Kosefoi	73	17	23
Sudjak	53	17	32
Bamfot	98	38	39
Bama	176	51	29
Bamus	138	59	43
Porters	61	31	51
Sausapor	112	60	54
Total	944	371	39

TANLE 23 - Tamrau Mountains

Sex and age distribution of individuals examined

Age	Males	Females	Total
0			45
1	16	8	24
2	17	3	20
3	20	4	24
4	20	7	27
5	15	7	22
6	10	16	26
7	12	18	30
8	20	12	32
9	17	6	23
10	9	6	15
11-15	32	45	77
16-20	49	31	80
21-30	136	95	231
31-40	119	82	201
41-50	40	24	64
51-	2	1	3
Total			944

TABLE 24 - Tamrau Mountains. Signs of trachoma according to age and sex

AGE	F		F+P		Mc.C. I+II		Mc.C. I+II	F+Sc		F+P+Sc		Mc.C. III		Mc.C. III	P		Sc		P+Sc		Mc.C. IV		Mc.C. IV	Total trachoma	% trachoma
	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	total	♂	♀	♂	♀	♂	♀	♂	♀	total		
0		9				9	9																	9	20
1	6	2			6	2	8																	8	50
2	11	3			11	3	14																	14	
3	8	3			8	3	11																	11	47
4	10	3			10	3	13																	13	
5	7	3		1	7	4	11	1				1		1										12	58
6	5	10	1		6	10	16																	16	
7	3	10		1	3	11	14								1						1		1	15	53
8	9	7	1	1	10	8	18																	18	
9	8	4			8	4	12																	12	47
10	4	1			4	1	5	1				1		1										6	
11-15	11	18	4	1	15	19	34									1						1	1	35	45
16-20	9	6	3	2	12	8	20	4				4		4	1	2	1				2	2	4	28	35
21-30	29	21	7	2	36	23	59	8	3	3	1	11	4	15	3		4	1	1	1	8	2	10	84	36
31-40	22	21	8	4	30	25	55	5	1	1		6	1	7	2	1	4	2	2		8	3	11	73	36
41-	9	2	1		10	2	12	2				2		2	1			1		1	1	2	3	17	25
																							Total	371	39

TABLE 25 - Prevalence of arcus senilis according to age groups in six New Guinea regions, expressed in percentage

Age group	Sentani	Upper-Digul	Radja Ampat	Mimika	Tamrau	Wissel Lakes
11-20	0	0	0	0	0	0
21-30	0	0	0	0.7	0.4	5.8*
31-40	7.5	4.9	3.8	5.2	11.9*	35.5*
41-50	24.3	21.9	25.2	25.4	42.2*	
51-60	36.2	40.9	43.4	41.5		
61-	50		68	81.8		

The percentages of the age group 51-60 years of Tamrau area and the age group 41-50 years of the Wissel Lakes have not been listed as these age groups comprise too few people (13 resp. 3)

TABLE 26 - Prevalence of immature cataract according to age groups in six New Guinea regions, expressed in percentage

Age group	Sentani	Upper-Digul	Radja Ampat	Mimika	Tamrau	Wissel Lakes
11-20	0	0	0	0	0	0
21-30	0.5	0.6	0.4	0	0	2.2*
31-40	4.2	7.8	3	2.9	2.5	25.8*
41-50	2.9	37.5	12.2	18.6	20.3	
51-60	23.4	90.9	48.2	50.8		
61-	33.3		80	81.8		

The percentages marked with an asterisk show a statistically significant difference from the overall percentages of the corresponding age groups of the Sentani,Upper-Digul, Radja Ampat and Mimika areas combined.

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